U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 170.

A. C. TRUE, Director.

REPORT

ON

AGRICULTURAL INVESTIGATIONS IN HAWAII, 1905.

BY

JARED G. SMITH,

Special Agent in Charge, Hawaii Agricultural Experiment Station.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1906.

U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 170.

A. C. TRUE, Director.

REPORT

ON

AGRICULTURAL INVESTIGATIONS IN HAWAII, 1905.

BY

JARED G. SMITH,

Special Agent in Charge, Hawaii Agricultural Experiment Station.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1906.

THE OFFICE OF EXPERIMENT STATIONS.

STAFF.

A. C. True, Ph. D.—*Director.*
E. W. Allen, Ph. D.—*Assistant Director and Editor of Experiment Station Record.*
W. H. Beal, A. B., M. E.—*Chief of Editorial Division.*
W. H. Evans, Ph. D.—*Chief of Division of Insular Stations.*
Elwood Mead, D. E.—*Chief of Irrigation and Drainage Investigations.*
John Hamilton, B. S., M. S. A.—*Farmers' Institute Specialist.*
Mrs. C. E. Johnston.—*Chief Clerk.*

HAWAII AGRICULTURAL EXPERIMENT STATION.

Jared G. Smith, B. S., M. A.—*Special Agent in Charge.*
D. L. Van Dine, B. S. A.—*Entomologist.*
Edmund C. Shorey, M. A., D. Sc.—*Chemist.*
J. E. Higgins, B. S.—*Horticulturist.*
F. G. Krauss.—*In Charge of Rice Experiments.*
Q. Q. Bradford.—*Farm Foreman.*
C. R. Blacow.—*In Charge of Tobacco Experiments* (*P. O., Paauilo, Hawaii*).

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., April 30, 1906.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 170 of this Office, a Report on Agricultural Investigations in Hawaii for 1905, by Jared G. Smith, Special Agent in Charge of the Hawaii Agricultural Experiment Station.

Respectfully,

A. C. True, *Director.*

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

REPORT ON AGRICULTURAL INVESTIGATIONS IN HAWAII, 1905.

The work of the Hawaii Agricultural Experiment Station has been continued along the same general lines described in previous reports. No changes were made in the staff, the various members of which submit their reports herewith. The special agent has given much of his time to administrative duties, superintending building operations, correspondence, preparing bulletins, etc. In the lines of investigation he has continued to give attention to a number of subjects that did not come in the field of the other members of the staff. The principal of these have been studies on grasses and forage plants, tobacco, cassava, coffee and cane diseases, tan-bark production, etc. The special agent and other members of the staff visited quite a number of localities in the Territory in the pursuit of their investigations, and by this means they have become acquainted with a considerable number of those interested in agriculture in its broad sense. Numerous additions were made to the equipment of the laboratories and library, and it is confidently asserted that the station now possesses the best agricultural library in the islands, it being especially strong along the lines of tropical agriculture, entomology, horticulture, and chemistry.

BUILDING OPERATIONS.

Considerable building was done during the year, and in addition to laborers' quarters there are now houses for the special agent, for the chemist, and for the entomologist. A much needed office and laboratory building has been provided; and as it is practically fireproof, the library and more valuable equipment of the station are safely housed for the first time. The laboratory and office building was provided out of funds appropriated by the Territorial authorities, supplemented by station funds. The building is 35 by 60 feet, with concrete walls, foundation, and floors, and a corrugated-iron roof. The station installed the floors, the foundation, and the larger share of the internal equipment. The inner walls and floors were built without a finishing coat, there being no ceiling, and the roof remained unpainted except in the chemical laboratory. The special agent in charge drew the plans, prepared the specifications, and gave the work his personal

supervision during construction, in order that the structure should be properly built. In addition to the laboratory building, the insular authorities appropriated $1,500 for a residence for the chemist. This was built by contract, but when turned over to the station was not suitable for occupancy and it required an expenditure of several hundred dollars to complete the work. In addition to these buildings, a number of necessary repairs have been made, and 1,000 feet of 2-inch pipe has been added to the water system of the station. The water supply from the city was extended by substituting 960 feet of 3-inch pipe for the same amount of 2-inch pipe on the central water main, thus making it possible to get city water 50 feet higher on the station grounds than before. A new 10,000-gallon tank for water supply for the residences was constructed and the one previously built was moved to a higher elevation, which results in an increased supply of water.

THE WATER PROBLEM.

With the extension of the water pipe and the building of new tanks some of the immediate necessities of the station are supplied, but as long as the station must depend on the Honolulu city water for irrigating purposes the supply will be inadequate to our needs. The tanks which have been depended upon for water supplies for the residences furnish only an amount sufficient for domestic purposes and offer little or no protection from fire. At present the buildings are without fire protection, as they are at a considerable distance from the Honolulu fire service. In order to meet the necessity for a more certain supply for irrigation purposes as well as to provide fire protection, a number of alternative plans have been drawn which contemplate the impounding in some way of the water at the higher level of the station grounds and conducting it to the lower lying tracts. At an elevation of 1,375 feet, on the upper part of the station grounds, there is a rainfall of more than 100 inches annually, while at the lower part of the station grounds, at a 100-foot level, the rainfall is only about 30 inches. It is believed that the abundant rainfall at the higher elevation could be collected in some way and applied to the lower part of the station, where it is impossible to carry on agricultural and horticultural operations without a permanent and adequate water supply. It is to be hoped that Congress will grant a special appropriation for supplying the necessities of the station in this respect.

FUNDS.

The appropriation made by Congress for the fiscal year 1905 was $15,000. In addition to this, Territorial appropriations were made amounting to $7,236, and the proceeds of sales of products of the station amounted to $1,153.70, making the total income from all sources

$23,389.70. The Territorial appropriations were for carrying on investigations in cooperation with the board of agriculture and forestry, and specific appropriations were made of $1,500 for the erection of a residence for the chemist, and $3,000 for a fireproof library, laboratory, and office building. The law specified that the latter building should be fireproof, but the sum appropriated was absolutely inadequate for a fireproof structure. As the money appropriated would lapse if not used during the fiscal year, the special agent believed it his duty to proceed with the building operations and complete them with funds derived from the other resources of the station. In doing this he used $3,487.30 for buildings and repairs, and $698.68 for fitting up the chemical laboratory, and $508.28 for reference books for the library. The amount spent for labor during the year was $3,369.57. The last session of the legislature adjourned without making any appropriation directly to the station, so that for the ensuing biennial period it will be dependent upon the amount appropriated by Congress and the sales of farm products.

INVESTIGATIONS.

The scientific work during the past year has been somewhat hampered by the construction operations before described. Nevertheless, a good deal has been accomplished. In cooperation with the Hawaiian Live Stock Breeders' Association a large amount of seeds of various grasses and forage plants were secured and distributed. Sufficient time has not yet elapsed to determine the success of this experiment, but it has already shown that fenugreek, Spanish sulla, woolly top (*Andropogon saccharoides*), and *Panicum bulbosum* are adapted to Hawaiian conditions. These recent introductions, together with others previously brought in by the station, are recognized by stockmen as having been of great value in restocking and extending their ranges, and this work will be continued for some time.

TAN-BARK PRODUCTION.

During the past year the special agent caused to be cut about 6 acres of black wattle (*Acacia decurrens*), which was growing on the station grounds at an elevation of about 700 feet above sea level. The soil at this place is a heavy decomposed lava, with frequent outcroppings of rock, and the slope is too steep to permit of any cultivation. The forest was planted about 1890 under the direction of the minister of agriculture of the then Hawaiian government, but had become overgrown by lantana. In addition the trees had reached full maturity and were beginning to die, about 10 per cent having died during the previous year. A galvanized-iron drying shed 30 by 50 feet was erected, and a force of laborers was hired to cut down the trees and

strip off the bark. A period of drought occurred while the bark was being stripped, so that many of the trees could not be successfully peeled. The bark strips were bundled and carried to the drying shed either on sleds drawn by horses or by wire trolley. A number of experiments were made to determine the cheapest commercial methods of handling the bark, which must be dried, chopped, and bagged before being marketed.

The station harvested from this tract 36 tons of dry bark, which was sold in Honolulu for $839.44, or at an average of $23.31 per ton. Twenty-five tons were shipped to Japan and the remainder was marketed in Honolulu and San Francisco. In addition to the bark the station secured 88 cords of firewood, which was sold to dealers in Honolulu for $689.25, or an average of $7.83 per cord. The total yield of bark and wood was at the rate of $254.84 per acre. In addition about 500 fence posts have been cut from the wattle grove during the past four years. The bark averaged from 28 to 37 per cent in tannin, and had it been sold according to the tannin content, or had there been a larger amount to market, better prices would undoubtedly have been obtained.

The special agent believes that wattle bark cultivation would prove a profitable industry in parts of Hawaii, as the trees grow as well in Hawaii as anywhere in the world. A yield of 6 tons of bark per acre would be considered a very low average, but if the trees were planted at a distance of 6 by 10 feet an acre should yield from 6 to 12 tons of tan bark in ten years, together with 30 cords of firewood. If wattle bark is to be produced on a large scale, the special agent believes that in preparing the bark for market it would pay to install a large, well-ventilated drying shed, with a tight roof and a number of stages of removable flooring, so as to cut the bark green, distribute it in thin layers, and dry quickly under shelter. This is contrary to the practice in Natal, where artificial plantations are maintained, but the climate of Hawaii is such that the bark can not safely be dried out of doors at the elevation where the trees are likely to be grown. The value of the bark would depend on its being protected from rain during the drying processes, as the tannin is readily washed out by water. Furthermore, the bark cuts better green than dry. The initial cost of drying sheds would be greater, but the probabilities are that the product would be more uniform and of a higher grade. It is believed that wattle cultivation would prove extremely profitable if a sufficient acreage were planted to enable the owner to market a definite amount of tan bark every year after the plantation reaches maturity. A bulletin (No. 11) upon this subject has been published by the station.

TOBACCO EXPERIMENTS.

In the autumn of 1903 a cooperative experiment was arranged under the joint auspices of the Territorial Board of Commissioners of Agriculture and Forestry and the Hawaii Station for the purpose of demonstrating the practicability of growing the best grades of cigar tobacco in Hawaii.

An examination of sites was made by Mr. F. E. Conter, formerly connected with the station, who, in the beginning, had charge of the work. Mr. Conter visited the Puna, Hilo, Hamakua, and Kona districts of the island of Hawaii, and finally selected a small tract on the Louisson Brothers' plantation on the lands of Pohakea, Hamakua. A lease of 2½ acres of the land was secured and special privileges were granted by the owners of the land, who have assisted the enterprise in every way in their power. The land was new and uncultivated, so that a delay of some months ensued before the field could be made ready for planting. The first crop was transplanted to the experimental plats in March and April, 1904.

The experimental tobacco field was located in Hamakua because the physical character of the soil was believed suited to the production of a good quality of crop. The Pohakea homestead lands were suitable, available, and convenient. There are doubtless other areas in Puna, Kau, and Kona, on the island of Hawaii, and on each of the other islands of the group, but at the time this experiment was undertaken the Pohakea tract was selected as the most convenient place in which to carry on field work.

SOME HAWAIIAN TOBACCO SOILS.

The texture of a soil—that is, the ratio between clay, silt, fine and coarse sand—is held to have much to do with the type of the product, and the color of the cured leaf, whether light or dark, its thinness and elasticity, depend, apparently, on soil characteristics and its water-holding capacity.

The soil on the Hamakua homesteads and on the Hamakua tract of land adapted to tobacco—a belt extending from Paauhau to Hakalau, at an elevation of from 1,000 to 2,500 feet—is a sandy forest loam, very rich in humus and with a high nitrogen content. The color of the soil is a light brown, becoming almost black when wet. The following physical analyses, made by Dr. Edmund C. Shorey, show the characteristics of these soils, and for comparison there is included an analysis of Sumatra soil, made by the Bureau of Soils of the U. S. Department of Agriculture.

Physical analyses of some tobacco soils.

Constituents.	Pohakea.	Kailua, Kona.	Rimboen, Sumatra.
	Per cent.	*Per cent.*	*Per cent.*
Organic matter and water	35.935	30.82	23.41
Gravel	16.511	11.85	.81
Coarse sand	11.337	13.25	1.44
Medium sand	6.716	3.95	3.62
Fine sand	14.002	8.42	13.94
Very fine sand	8.339	28.25	19.52
Silt	5.848	1.75	23.51
Clay	.940	.85	2.72

A chemical examination of the Pohakea soils showed that although the "iron and alumina" content is high the percentage of clay is very low. The "fine gravel" and "coarse sand" are really reducible to "fine sand" and "very fine sand" if the soil is shaken in water for longer than the customary period previous to analysis. There is almost no true clay in this soil, and practically no true gravel or coarse sand.

The lime is present as a silicate and is too low in quantity to neutralize the acidity. The potash content is very low. Nevertheless, a dressing of sulphate of potash applied to the experimental plats at the rate of 500 pounds per acre produced cigar leaf of exceptionally good burning qualities. The nitrogen, although high, is largely unavailable, so that it will pay to use moderate amounts of nitrate on the crop. The phosphoric acid is presumably largely unavailable.

On cultivation the coarser particles of Hawaiian soils rapidly disintegrate. The shotty particles, technically classed as "fine gravel" and "coarse sand," when worked with rubber pestles or rubbed between the fingers are easily crushed to a fine powder. The ultimate soil grains are agglutinated in masses because of the exceptionally large percentage of organic matter in the soil.

The tobacco soils of Hamakua and Kona are very similar in all their characteristics, and probably the Kona district is better adapted to tobacco cultivation than Hamakua because of the protection from strong trade winds.

CLIMATE.

The influence or climate on the growing of tobacco is always held to be a potent factor. Cigar tobaccos of good quality are produced through a wide range in latitude. Proximity to the ocean has always been considered a deterrent influence.

Tobacco requires from 70 to 100 inches annual rainfall, from one-half to one-third of this during the growing season. Moderate temperatures, frequent showers or irrigation, to promote even, uninterrupted growth, neither too rapid nor too slow, constitute an important element in determining the suitability of any district where soil conditions are correct. The slight variation of daily and seasonal

temperatures is characteristic of Hawaii, so that the rainfall or the ability to irrigate the crop when required become of greater importance than any consideration of actual temperatures.

In the windward districts protection from wind must be provided (Plate I, fig. 3). This may be accomplished either by tenting the field with cotton cloth, as in Connecticut and Florida, or permitting the larger ohia trees to remain when the land is cleared; or, in case tobacco is planted on lands cleared for cane or other "open-field" crops, by planting or constructing suitable wind-breaks. In the leeward districts the protection from wind may be neglected.

After comparison of results in Hawaii with those obtained elsewhere in growing tobacco of fine quality, it is believed that uniformity of temperatures, with sufficient moisture during the growing season of the plant, have as much to do with the quality of tobacco as any other physical or climatic factor. If this be true, the remarkable monotony of temperatures and narrow variations, daily, monthly, and seasonal, should make it possible to grow in Hawaii fine tobaccos which will in time be classed as distinct from those of any other land.

CULTIVATION, CURING, ETC.

One of the main requisites for success in tobacco culture is to have good, strong, healthy plants ready to transplant to the field at the proper time. Good seed is the first essential in their production, for without good stock to start with, one can hardly expect to obtain the best results.

An open seed bed, as is used in other countries, would prove a failure in Hawaii. Insects are too numerous and the soil too full of humus to stand burning. Two methods can be recommended. The first of these is elevated boxes, set about 20 inches from the ground on posts, the box level and projecting at least 6 inches outside the posts, 3½ to 4 feet wide, 10 to 12 feet long, and at least 6 inches deep. Fill full with good soil, sifted to remove sticks, trash, and stones, the last inch being finer, so that the seed, which is very small, may come in closer contact with the soil, but not be covered too deeply. Add a pound or two of air-slaked lime and mix well with the last 2 inches of top soil filled into the boxes or beds. The seedboxes, when the seedlings show up, should be covered with a gable-roofed frame, covered with cheese cloth or light, open cotton. This cover retains the moisture, maintains a more nearly uniform temperature, and wards off insects.

The other method is to build a large cloth house, with gable roof, and in it arrange the beds so as to permit ready passage among them. The elevated boxes, for a few plants, are the easier to make and care for. In an excessively rainy period the boxes do not drain off the water as well as the beds and become cold and soggy. For growing a large number of plants the seed house is to be preferred.

All seedboxes and beds should be sterilized to kill insects and their eggs. An easy way to do this is to use from 10 to 20 gallons of boiling water, applied as evenly and quickly as possible and cover with some kind of a blanket to retain the heat. A pair of saddle blankets answers the purpose nicely.

After the seed beds become cold they are ready for the seed, and if the top has become packed it should be loosened and made fine.

Tobacco seed should be sown thinly, so the plants have room to grow. Each plant should have at least 1 square inch of surface to make a sturdy plant. Seed beds should, at all times, be fairly moist, and never be allowed to become dry or to show dryness on the surface. The seed is small and is only planted on the surface. Good seed should germinate in from twelve to fifteen days. In from six to eight weeks the more hardy plants will be ready for the field, and the others will follow in quick succession until the bed is exhausted of all desirable plants.

Young plants should be allowed considerable sunshine to harden them before transplanting.

PLOWING AND TRANSPLANTING.

The land selected for a tobacco field should be such as can be plowed both ways. It should be sheltered from the high trade winds that sometimes blow with great force. Small square plats of from 2 to 5 acres each would form good fields for a small planter, especially if surrounded by the forest. It is well to plow the land some little time in advance of the planting.

Tobacco being a tap-rooted plant, in some instances sending its roots down to a depth of 2 feet or more, requires that tillage shall be deep in preparing the land to receive the young plants. The soil should be plowed to a depth of at least 12 inches, and the work should be done in such a manner that the subsoil is not brought to the surface. Have the soil fine and loose but leave the sterile, acid subsoil underneath where nature placed it. Put the soil in good, mellow condition, as it pays to do so for any crop.

As soon as the land is plowed and harrowed, the field should be poisoned to kill pokos or cutworms (Plate I, fig. 4), army worms, Japanese beetles, and the various pests usually abundant in newly turned land. There are two remedies which are of about equal value. Sow one or the other of the following broadcast over the newly plowed land:

Arsenicated horse manure.—To 40 pounds of dried, fresh horse manure, as free from straw as possible, add 6 to 8 ounces Paris green mixed with 5 pounds of common salt. Stir until the salt and Paris green are thoroughly incorporated in every part of the manure. This amount is sufficient for 1 acre.

FIG. 1.—HAVANA SEED LEAF, PLANT 3 FEET 9 INCHES HIGH.

FIG. 2.—VUELTA ABAJO, UNDER SHADE, PLANT 6 FEET 6 INCHES HIGH.

FIG. 3.—PLAT OF YOUNG PLANTS.

FIG. 4.—WORK OF CUTWORMS ON LEAVES.

Poisoned bran.—To 2 pecks of bran or coarse corn meal add 4 ounces Paris green or 8 ounces disparene and 2 quarts of molasses or honey or 5 pounds coarse sugar. If sugar is used, moisten the bran with water. Stir and mix thoroughly and scatter over the field.

Poisoned horse manure is safer than poisoned bran and somewhat cheaper. Pokos and army worms like it fully as well as the sweetened bran, and cattle, chickens, and other domestic animals are less liable to be poisoned through eating it. The Japanese beetle seems to prefer the poisoned bran.

The field being prepared and the plants ready, they can be set out at any time of the year when the soil is in a moist condition and the sky is clouded. Plant only good, strong, healthy plants in the field. It is poor economy to set a sickly plant anywhere and give it care and cultivation, with but little chance for a return from it for the time and labor expended.

If the sun is shining when the seedlings are transplanted, the young plants need some shade until they start. Ti leaves make a good shade. Stick the stem end into the ground and bend it over the young tobacco plant and fasten the other end with a handful of soil laid upon it.

In Hamakua tobacco can be set at any time and will grow, but it will grow better and faster from February to September (warm weather), although, if set in September and October, if the ground is wet, it will make enough growth to mature a crop during the cold weather.

Care should always be used in handling young tobacco plants, as the leaves and shoots are very brittle and tender and break easily. Tobacco should be planted on slightly raised ridges, some 3 or 4 inches higher than the surrounding ground, as it facilitates drainage and places the plants in a more decided position and less liable to injury through cultivation.

The distance between the plants in the row and the width of the rows is governed by the kind of tobacco planted and the use to which the finished leaf is to be put, whether wrapper or filler. The right distance to plant must be determined by each planter to suit the type of tobacco grown and the character of the soil. In Hamakua the cigar tobaccos, such as the Cuban, Sumatra, Connecticut Seed Leaf, and Zimmer Spanish, do well 15 inches in the row and 3 feet 5 inches between rows. An acre set at this distance contains about 10,000 plants. The manufacturing tobaccos, producing a larger leaf, require more room each way and should be set 2 feet 4 inches apart in rows 4 feet apart..

In about seven to eight weeks after setting in the field the plant will send up a head or seed cluster, which should be removed in all cases before any of the flowers open.

31208—No. 170—06——2

HARVESTING AND CURING.

Between the time of planting and harvesting a tobacco barn must be provided large enough to care for the entire crop. This structure should be of lumber rather than galvanized iron, with shingle roof, hinged frieze, or gable ventilators, and the sides provided with vertical ventilators extending from sill to plate, the idea being to secure complete control of temperature and air drafts within the building during the curing process.

A tobacco barn, properly constructed, should last for twenty years. In Hamakua, at the elevation where our tobacco experiment is being conducted, a stove must be provided to heat the air and control moisture because of the frequent periods of fog and cloudy weather. This stove is placed outside of the shed, with the pipe or flue passing either across through the house from side to side or, inside a large barn, around two or more walls.

In Hamakua the curing process requires from two to four weeks. The determination of the proper time to harvest tobacco leaves is a matter of judgment and experience. Leaves that are underripe cure greenish, thin, papery, and brittle. Those overripe become harsh, thick, and of uneven color. A ripe leaf cures gummy, pliable, elastic, and of an even color.

Each kind of tobacco has its special characteristics and must be treated accordingly. Cigar tobaccos require slower barn curing and more careful manipulation during the whole period of growth, curing, and fermentation than do the cheaper grades of manufacturing and export tobaccos.

The fermentation of the tobacco follows the curing. This is a very important step in the process and is fully described in Press Bulletin No. 12 of this station. In Hawaii the period of fermentation lasts sixty to ninety days. Five pounds of green leaf produce about 1 pound of finished tobacco.

RESULTS OBTAINED AT HAMAKUA, 1904.

The crop planted during March and April, 1904, was the first systematic and scientific attempt to grow tobacco in Hawaii. An acre was covered with an open-weave cotton cloth, Ariel tenting cloth, put upon plates and posts, forming a flat roof about 9 feet above the ground; the sides were also covered with the same kind of cloth, making a tight inclosure. This covered plat, with some land adjoining, about $1\frac{1}{4}$ acres in all, was planted as follows: Sumatra, Florida and Long Stem; Cuban, Florida and Vuelta Abajo; Connecticut Broad Leaf and Seed Leaf; Zimmer Spanish; Virginia Dark Leaf; White Burley; and Japanese.

A good many plants under the cloth shelter were killed by the drip from the seams, wires, and plates of the structure. This first year's work demonstrated quite clearly that tenting tobacco is not a success in Hawaii, at least in regions of high rainfall.

The following field notes may be of interest and value:

Sumatra.—Sumatra tobacco averages 8 to 9 feet in height and tops at about 7 feet. One thousand plants produced 19,309 leaves, weighing, green, 684 pounds, or 137 pounds of finished tobacco. The average per plant was 19.3 leaves, weighing 11.5 ounces, and the estimated yield per acre containing 9,680 plants was 6,332 pounds of green leaf, which would make 1,260 pounds of finished tobacco.

Florida Cuban.—This tobacco grows 5 to 7 feet in height and tops at 4½ to 5½ feet. Each plant yielded on an average 10.6 leaves, weighing, green, 6.8 ounces. Florida Cuban tobacco will stand planting 15 inches apart in rows 3 feet apart, or at the rate of 11,500 plants to the acre. The estimated yield per acre on the basis of the yield obtained is 4,870 pounds of green leaf, or 970 pounds of finished tobacco.

Vuelta Abajo, Cuban.—This is a low-growing tobacco, averaging about 4½ feet and topping at 3 to 3½ feet. (Plate I, fig. 2.) Two hundred and ten plants yielded 1,500 leaves. The average per plant was 7.2 leaves, weighing, green, 3.4 ounces. This tobacco would stand planting 12 inches apart in rows 3 feet apart, or at the rate of 14,500 plants per acre. The estimated yield per acre is 3,080 pounds of green leaf, or 616 pounds of finished tobacco.

Connecticut Broad Leaf.—This tobacco grows 4 to 6 feet tall and tops on an average at 3 feet 8 inches. Some of the leaves were 37 inches long by 16 wide. The average per plant was 15.1 leaves, weighing 1 pound. This tobacco is planted 18 inches apart in rows 42 inches apart. It should have been spaced wider, at least 30 inches in the row and 48 inches between rows. Our yield was at the rate of 7,820 pounds of green leaf or 1,560 pounds of finished tobacco. Connecticut Broad Leaf is difficult to cure because of the extraordinary thickness of the midrib and lateral veins. None of the other varieties of tobacco grown were weighed or measured.

Connecticut Seed Leaf cured lighter than any of the other tobaccos and gave a thin, light leaf, fit for wrapper. In the curing shed this molded very badly. *White Burley* would not cure or even dry without molding. It will require a high heat to cure. It is a pipe tobacco and is also, to some extent, used as a filler in cheap, domestic cigars.

Japan tobacco is about the same as the Broad Leaf, a wide leaf, not quite so long but with a large midrib. It is a pipe or cigarette tobacco.

Zimmer Spanish cured very dark, harsh, dry, and brittle, and did not absorb much moisture even in a rainy time. It is used for filler in the cheaper grades of domestic cigars.

After curing and fermenting the crop, samples were submitted to a number of experts and cigar manufacturers and the quality of some varieties was pronounced excellent. This was especially true of the Cuban types, cigars made from this crop equaling many of the well-known brands of Key West and Cuban cigars. A prominent Philadelphia manufacturer, reporting on samples submitted, says: "The burning quality of your sample is exceptionally good. In our estimation it makes a finer smoke to mix with Havana tobacco than any of our ordinary domestic tobaccos to-day on the market, and by all means the pleasure and taste is very much superior to tobacco grown in Florida, which is now so successfully used by numerous manufacturers in Tampa and Key West posing as clear Havana manufacturers."

HAMAKUA EXPERIMENTS, 1905.

The results indicated at the close of the season of 1905 are that wrapper tobaccos of fine texture and body, and filler leaf of mild flavor and good burning qualities, are a commercial possibility. The chief fault to be overcome lies in the direction of the production of light colors, the greater percentage which have been produced being of shades darker than the present market fashions demand. In flavor the filler types are intermediate between the Manila and the Cuban, so that if producers undertake this industry on a practical scale, the indications are that the Hawaiian leaf can be marketed, to a certain extent, on its own merits, rather than in competition with either the Cuban or the Manila cigar tobaccos. As the color of the finished product can be almost absolutely controlled by the method of cultivation and of manipulation in curing and fermentation, that phase of production need not be considered a serious drawback. While at the beginning of the experiment artificial shade by the use of tenting cloths was attempted, the 1905 crop was grown in the open, entirely without shelter other than that due to the fact that the experimental plat is surrounded on all sides by forest, and the indications are that tenting is absolutely unnecessary in Hawaii. It so happens that the districts having tobacco soil in considerable area are mostly located at an elevation of from 800 to 2,000 feet, which zone constitutes the so-called cloud belt of the islands. While it does not rain every day, the clouds gather on this portion of the mountain slope almost invariably during each afternoon, while the mornings are bright with clear sunshine. It is believed that the natural climatic conditions together with the physical conditions of the soil are the causes which lead to the production of filmy texture and silkiness, with elasticity—the characters absolutely essential to wrapper leaf of high quality. In addition to the wrapper and filler leaf, a crop has been grown of broad-leaf tobacco of the binder type, in regard to the quality of which experts have made extremely favorable reports.

About 20 per cent of the crop of Sumatra tobacco grown in 1905 was of excellent quality as regards texture and body, while only about 10 per cent of the whole crop showed desirable shades of color. This 10 per cent has been valued by tobacco experts as worth from $2 to $4.50 per pound. The yield in the experimental plats has been at the rate of about 1,000 pounds per acre. The balance of the crop, unsuited for wrappers, commands only a very low price, perhaps on an average not more than 10 cents per pound. The tobaccos of the Cuban type (Pl. I, fig. 1) yield considerably less than tobaccos of the Manila, Hawaiian, Japanese, and Sumatra types, but whatever percentage is left after the wrapper leaf has been selected is salable as filler at prices ranging from 15 to 40 or 50 cents per pound. The yield of Cuban leaf ranges from 450 to 600 pounds per acre, and fully 25 per cent of the 1905 crop would have been suitable for wrapper leaf had the colors been lighter.

There are at least 100,000 acres of land in Hawaii where the physical character of the soil is right for growing tobacco. The largest areas are on the island of Hawaii, in the Hamakua, Olaa, Puna, Kau, and Kona districts. There are also available tobacco lands on Maui, in the district between Makawao and Ulupalakua, and smaller areas on Oahu and Kauai.

An estimate has been made that if a grower produces tobacco on his own land, and with his own labor or that of his family, the green leaf can be produced at a cost of about 2 to 2½ cents per pound, equal to 10 to 12½ cents per pound for barn-cured tobacco.

The yield of Sumatra tobacco ranges from 750 to 1,000 pounds of cured leaf per acre. The broad leaf binder types yield from 1,000 to 1,400 pounds, and the Cuban filler and wrapper types from 450 to about 600 pounds.

Unless growers have a considerable acreage they can not themselves ferment their crop to the best advantage. This end of the industry will undoubtedly have to be handled by corporations. While knowledge of tobacco curing in other countries will be extremely valuable to those entering upon this industry in Hawaii, nevertheless the climatic requirements are such that local agricultural experience will be of almost equal value. The old Hawaiian native or Manila type of tobacco grows wild all over the islands, from sea level up to the frost line. It has been grown so long without cultivation, or with only the crudest care, that the plant has apparently reverted to the original type. The leaves cure a very rich brown color, but are thick, heavy, and leathery, with so much gum that even after being fermented the burn is very poor. The old Hawaiians, however, recognize certain limited districts as producing tobacco of flavor and strength suitable to their requirements and taste, with burning qualities which are better than the average.

These districts are in almost all cases quite near the ocean. They are located near Hana, Maui; in certain localities on the island of Niihau; in Kona and Kohala, on Hawaii, and in the vicinity of Waimea, on Kauai. Tobacco cultivation was also at one time a considerable industry among the native Hawaiians in the district around Naalehi, in Kau. The best grades of these Hawaiian tobaccos are sold to natives and Chinese at the rate of 25 cents for twenty-two leaves, or at about 50 cents per pound.

The outlook for the tobacco industry in Hawaii is very good. While to a certain extent a market must be created before the production of filler types of tobacco is undertaken on a large scale, there is sufficient demand for wrapper leaf of the better qualities to make the cultivation of these types of tobacco a sure success, even though the crop must be marketed in open competition with leaf imported into the United States from Cuba and Sumatra.

RUBBER CULTIVATION.

The cultivation of rubber-producing plants is engrossing attention in all tropical lands, and recently many inquiries have been received at the station as to the species most liable to prove a successful introduction into Hawaii. To supply this information the special agent in charge prepared a press bulletin based upon observations on specimen trees growing in various parts of the islands and upon recent articles in journals devoted to tropical agriculture. Hawaii, with its subtropical rather than thoroughly tropical climate, is probably limited to a few species of rubber-producing plants. Of the better known species two have been shown to be adapted to Hawaiian conditions, the Ceara rubber (*Manihot glaziovii*) and the Assam or common rubber tree of gardens (*Ficus elastica*). In favorable situations the Ceara rubber trees will make a rapid growth in Hawaii, apparently thriving from sea level to 2,500 feet elevation, both on the wet and dry sides of the islands. There are a number of trees of this variety growing on the station grounds that were planted in 1893. One of the best specimens stands in a clearing near the Tantalus road, where it received some spasmodic attention. This tree is now 40 feet high, with a trunk 10 inches in diameter. Others planted at the same time, but totally neglected and overrun by lantana and shaded by eucalyptus, are only 10 to 15 feet in height and an inch or two in diameter. The Assam rubber is somewhat slower of growth in Hawaii, but it is believed to be one of the most promising rubber trees for plantation culture in such districts as Hilo, Puna, Olaa, and Nahiku. This species will withstand low temperatures, that are extremely detrimental to Para and Central American rubber trees.

From what is known regarding the adaptability of rubber trees in

Hawaii, it is believed that the Ceara rubber tree should comprise the larger proportion of all new plantations, because of its extremely rapid growth and early maturity. In laying out a rubber plantation comparatively early returns are desirable. The Ceara trees will stand a moderate tapping, when three years old, and may be counted on to yield a considerable return in five years. The Assam rubber tree, while of much slower growth, yields much more abundantly when it does finally reach bearing age. A number of other varieties are believed worthy of trial, as they are reported native of high elevations where the climatic conditions are similar to those of the Hawaiian mountain slopes. The conditions in Hawaii are believed to be extremely favorable for the cultivation of Ceara rubber trees, and one of the newly formed companies has already planted 100,000 seeds of this species and expects to have half a million trees growing within two years. It is believed that with as much science, skill, and knowledge devoted to rubber planting as is now given the sugar industry there will be no question of ultimate success in this new industry.

CASSAVA.

Considerable attention has been recently given throughout tropical and subtropical regions to cassava cultivation. This plant is well known to the native Hawaiians as a food plant, bearing the name pia, which was used by the older generation for the native arrowroot (*Maranta arundinacea*). While cassava is used for forage and as a vegetable, its more important use is for the preparation of starch, known commercially as tapioca flour. There is one small factory in operation on Kauai, but the plant is not a modern one and the business is conducted rather as an adjunct to cattle feeding.

In Hawaii cassava grows as a perennial, although commercially it is best to treat the crop as an annual. It thrives from sea level on the Kona side of most of the islands up to 3,000 feet elevation, except in very wet districts. It requires about the same soil as sweet potatoes and maintains an existence for a surprisingly long time, even under the most adverse conditions of neglect. A few plants are usually to be seen in the gardens of native Hawaiians, who give them less care and attention than they bestow upon their sweet-potato crop. If the production of this crop is undertaken on a commercial scale, the land should be selected so that it can be given the proper cultivation. Shallow plowing, 6 to 12 inches, is preferred to deeper cultivation, as it tends to keep the roots nearer the surface and facilitates harvesting. After the land is thoroughly prepared the seed, which consists of cuttings of the stalk, are planted in furrows 2 to 4 feet apart. The best results obtained in Hawaii are from plantings made from November to February. A field should be cultivated sufficiently to keep down the

weeds, and at the end of the wet season the plants will be high enough to care for themselves in this respect. No irrigation is required, but a moderate application of low-grade fertilizer is recommended. As Hawaiian soils are mostly lacking in potash, this element should be used rather freely.

When planted as directed above, the roots will be ready for harvest the following October or November. The roots will remain for a long period in the soil, and if allowed to grow for two years will greatly increase in size and weight, but the increase is at the expense of the starch. The two-year-old roots are often hard and fibrous, containing little starch. Cassava rots quickly after being dug, seldom keeping for more than a week. However, as long as the roots remain in the ground they will not rot unless the plants are diseased. Mice, borers, and field cockroaches attack the roots, and on this account it is believed advisable to treat cassava as an annual. A yield of 5 tons of cassava roots per acre is about an average, although yields of from 5 to 10 tons may be counted on in good land with favorable seasons.

It would seem that the cultivation of cassava for starch or glucose manufacture might be profitably carried on in connection with the fattening of cattle and hogs for market. The area available for the cultivation of cassava in Hawaii is large, and it is a crop which does not require large investments for the field operations of plowing, planting, cultivation, and harvesting.

PUBLICATIONS.

During the year three regular bulletins and four press bulletins were issued.

Bulletin No. 8, Methods of Milking, describes the Hegelund or Danish method of milking and gives the result of a thirty days' trial of this method at the Kamehameha Boys' School dairy.

Bulletin No. 9, Citrus Fruits in Hawaii, gives the results of investigations by the horticulturist of the station into the present condition of citrus-fruit growing and suggests methods for the restoration and development of this industry. In addition to describing standard varieties of various citrus fruits the author calls attention to a number of native seedlings that are believed worthy of more extended propagation.

Bulletin No. 10, Insect Enemies of Tobacco in Hawaii, gives an account of the insect enemies of tobacco in Hawaii and suggests methods for their control.

Press Bulletin No. 11, The Common Liver Fluke in Hawaii, calls attention to the common occurrence of liver flukes in cattle, sheep, and other domesticated animals, and, after describing the parasite and symptoms of the disease, suggests methods for its control.

Press Bulletin No. 12, Tobacco in Hawaii, gives an account of experiments carried on by the station at Hamakua, Hawaii, in growing tobacco. The experiments, which had been in progress for but a single year, seemed to indicate the possibility of growing cigar tobacco of good quality in certain regions of the islands.

Press Bulletin No. 13, Rubber in Hawaii, gives compiled information regarding the rubber-producing trees and vines of the world, describes specimens already growing in the islands, and gives suggestions for planting and cultivating rubber trees.

Press Bulletin No. 14, Fuller's Rose Beetle, describes one of the most injurious beetles of Hawaii, where it is known as the "Maui" or "Olinda beetle." It feeds on a wide range of economic plants, and remedies are suggested.

REPORT OF THE CHEMIST.

By E. C. Shorey.

The beginning of the fiscal year 1905 saw the chemist still occupying the small building serving as office, library, and laboratory. In the temporary laboratory fitted up in this building the soil work and preparation of fodder samples, noted in the last report, was continued.

In the case of fodder samples the method of preparation was as follows: A weighed quantity, usually 500 grams, of the green fodder was chopped and air dried, weighed again, the loss on air drying being recorded. The whole of the air-dried sample was then ground and passed through a 0.5-millimeter sieve, and a portion stored in an air-tight sample bottle. Quite a number of samples so prepared were rendered useless for purposes of analysis by the ravages of the cigarette beetle (*Lasioderma serricorne*). In some cases the beetles made their appearance three weeks after the samples were stored. This preparation of fodder samples and a continuation in a small way of the work on soil nitrogen was the only work done in the temporary laboratory.

NEW LABORATORY.

The new laboratory was completed in October, and moving in and fitting up took about one month. The water and gas pipes and some shelving not included in the contract were put in with station labor. The main room of the laboratory is 25 by 35 feet, with a small nitrogen room partitioned off from one corner. Adjoining the main room are three small ones—an office, a balance room, and a dark room. The main room is well supplied with worktables, sinks, and hoods. There are sinks and hoods in the nitrogen room and a sink in the dark room. The worktables are well lighted, and with a slight increase in equipment it would be possible for three chemists to work without

inconvenience. The present gas supply is that furnished by the small gas machine used in the temporary laboratory, and the supply is so small that work is practically confined to one thing at a time. The Honolulu Gas Company is at present laying mains in the city, and it is hoped that they will soon have a main near enough the station for gas to be obtained from that source.

A few additions of standard reference works were made to the library during the year. Among these was a complete set of Hoppe-Seyler's Zeitschrift für physiologische Chemie.

LABORATORY WORK.

The laboratory work may be divided into three classes: (1) Routine work; the analysis according to official or well-approved methods of materials, such as soils, fertilizers, and fodders, to determine total or partial composition. (2) Miscellaneous work; the examination of samples of a miscellaneous character to determine composition, value, or adaptability for special purposes. This work for the most part is undertaken at the request of individuals, and quite often the satisfactory answer of such inquiries entails research work, the devising of new methods of analysis, search for new compounds, or the application of known facts in explanation of new or little understood conditions. (3) Research work proper. The work done in the new laboratory from November, 1904, to June 30, 1905, may be noted under these three heads, as follows:

ROUTINE WORK.

This was confined to analysis of fodder samples. These analyses were made by the official method, and, in addition to the usual analysis, determinations were made of albuminoid nitrogen, potash, lime, and phosphoric acid. The object in making these analyses was to furnish material for publication on the composition of Hawaiian-grown fodders, and, in the meantime, supply data sufficient to answer some of the frequent inquiries which come to the station regarding the composition of such material. Sixty-three samples were analyzed, the more common fodders being represented by from two to six samples. A large number, however, are as yet represented by but one sample each. As quite a number of fodders, especially grasses, are as yet not represented in this series, and as in nearly all cases the samples are too few to establish maximum, minimum, and average composition, it is the intention to continue this work during the coming year. It is also the intention to complete the ash analyses of these samples, and it is hoped to supplement the analysis of Hawaiian-grown fodders by feeding experiments, in cooperation with individuals or institutions having dairy or other stock.

MISCELLANEOUS WORK.

Fifty samples of soil have been turned in to the laboratory, sent either by private individuals or collected by members of the station staff in various parts of the islands. Fifteen of these samples have been examined and reported on. In a number of cases the samples were of such a character or the data supplied were so meager that time spent on them would have been wasted. In such cases further information and reliable samples have been sought. Twenty samples of those on hand will be examined as rapidly as the facilities of the laboratory will permit. The soils examined include those devoted to tobacco, bananas, and cacao on Hawaii and pineapples on Oahu. The official method, digestion with hydrochloric acid, specific gravity 1.115, has been used throughout, and in giving advice based on these analyses due regard has been given the various factors bearing on this matter noted in the last report.

Three samples of honey, marked, respectively, grades 1, 2, and 3, were submitted by a local producer with the statement that the price obtained had not been as good as expected, and asking if analysis would show any difference in the samples or anything to justify the buyer's objection to the quality. Analysis showed almost the same composition, except in moisture content, the figures being as follows: No. 1, 15.79 per cent; No. 2, 17.34 per cent; and No. 3, 18.70 per cent. It was learned after reporting as above that the buyer objected to the amount of water in the lower grades, and it was suggested that this was due to uncapped or partially capped unripe honey being included in those grades.

The manager of a local cannery making guava jelly reported that a portion of the season's output was unsalable, owing to the more or less liquid condition of the article, and that in the same lot some jars were of good quality and others made in the same way were defective. Samples were submitted, but analysis did not disclose any reason for this behavior. It was evident that a remedy for this trouble could be arrived at only by a study of the composition of guavas at different stages of ripeness, as well as a study of the method of manufacture in the cannery. This, so far, it has not been possible to do.

Samples of wattle bark (*Acacia decurrens*) were examined for percentage of tannin, and this found to vary from 29 to 35 per cent on the weight of the air-dried bark. These were samples of bark harvested and shipped from the station during the year. Two samples of koa bark (*Acacia koa*) were also examined for tannin content and found to contain 12.69 and 17.51 per cent. These samples were obtained from Hawaii.

The Hawaiian Fiber Company submitted samples of the waste wash water from the sisal cleaning machine, with the request that if pos-

sible some use be found for this material. This wash water is the juice of the sisal leaves, with the water added in cleaning the fiber. In this dilute condition the organic content is low, the ash rather high, and 70 per cent of the ash lime. From examination of the samples it did not seem likely that any better use could be made of the waste water than is now being made, viz, returning it to the land. The same company submitted samples of sisal waste, i. e., the short fibers from the butts of the leaves, with a request that its value for paper making be determined. Crude paper has been made from this material, but the determination of its value and the best method of treatment can be made satisfactorily only in a paper mill or a laboratory properly equipped for such work, which this laboratory is not.

Samples of granulated sugar (2), condensed milk (1), guano (3), and canned pineapple (1), of no special interest except to those asking for the analyses, were analyzed and reported on.

Miscellaneous work of this kind of course calls for correspondence. Some of this was obviated by the possibility of personal interview with inquirers. There has also been some correspondence where no samples were submitted. With the idea in mind that the dissemination of knowledge is not the chief work of an experiment station worker, the aim has been to keep correspondence in as subordinate a position as was consistent with the answering of reasonable inquiries. With slight encouragement this miscellaneous work and correspondence would increase so as to take the chemist's whole time. The chemical work at this station is free from many of the things which tend to retard special work. There is no teaching, no fertilizer, feeding stuff, nor food control; but miscellaneous consulting work spread over the whole field of chemistry is really more distracting to one trying to follow some special line than teaching or routine analyses, where the work is carried on along certain well-defined lines.

RESEARCH WORK.

The nature of the research work undertaken, an investigation of the nature of the nitrogenous compounds in Hawaiian soils, was briefly explained in the last report.

While in the temporary laboratory two matters supposed to be intimately connected with this subject were taken up chiefly because there were not at that time facilities for other work. These were soil acidity and denitrification. Acidity determinations, according to the method proposed by Hopkins, Knox, and Pettit,[a] were made on all the samples of soil on hand—twenty-five. Two only of these were acid to litmus when moistened with water, but all gave more or less acid solutions when extracted with 5 per cent salt solution. This

[a] U. S. Dept. Agr., Bureau of Chemistry Bul. 73, p. 114.

acidity, when calculated to the equivalent amount of calcium carbonate, varied from 300 to 700 pounds for 1 acre of soil to the depth of 1 foot. How far this method is applicable to Hawaiian soils is yet to be determined, and efforts are being made to do this by field tests. The acidity shown by this method evidently does not interfere to any great extent with nitrification, for the samples examined contained nitrogen as nitrates varying from 15 to 55 parts per million. In determining the nitrate in these soils the method used was to add 500 cubic centimeters of water to 100 grams of soil, shake 3 minutes, let stand 20 minutes, filter, and determine nitrates in 100 cubic centimeters of the filtrate by the phenol-sulphonic acid method. It was found that in cases when the soil and water had been allowed to stand overnight (14 hours) the nitrate had much decreased, and in some cases disappeared altogether. This applied to all the soils examined, and occurred whenever the soil stood for some hours saturated with water. The following example will illustrate this:

	Parts per million.
No. 1. 100 grams of soil, 500 cubic centimeters water; shaken 3 minutes, let stand 20 minutes; nitrogen as nitrate	32.5
No. 2. 100 grams of soil, 500 cubic centimeters water; shaken 3 minutes, let stand 1 hour; nitrogen as nitrate	47.5
No. 3. 100 grams of soil, 500 cubic centimeters water, shaken 3 minutes, let stand 22 hours; nitrogen as nitrate	4.0
No. 4. 100 grams of soil, water to saturation (75 cubic centimeters) added, let stand 22 hours; 425 cubic centimeters water added, shaken 20 minutes; nitrogen as nitrate	4.0

With another sample of soil from the same place the time factor was determined roughly by saturating 100 grams with 75 cubic centimeters water and proceeding as above in No. 4, varying the time. The results were as follows:

	Parts per million.
Stood 2 hours; nitrogen as nitrate	40
Stood 4 hours; nitrogen as nitrate	40
Stood 6 hours; nitrogen as nitrate	40
Stood 8 hours; nitrogen as nitrate	40
Stood 10 hours; nitrogen as nitrate	40
Stood 12 hours; nitrogen as nitrate	15
Stood 13 hours; nitrogen as nitrate	4
Stood 14 hours; nitrogen as nitrate	4
Stood 15 hours; nitrogen as nitrate	4

Soil from another place, by treatment as above, gave the following figures:

	Parts per million.
Stood 1 hour; nitrogen as nitrate	35
Stood 12 hours; nitrogen as nitrate	30
Stood 16 hours; nitrogen as nitrate	25
Stood 20 hours; nitrogen as nitrate	11
Stood 24 hours; nitrogen as nitrate	11

The influence of varying amounts of water is shown roughly by the following figures. The soil treated contained 38 parts of nitrogen as nitrate per million and required 75 cubic centimeters to saturate it.

	Parts per million.
75 cubic centimeters water added, let stand 24 hours, nitrogen as nitrate	0.5
65 cubic centimeters water added, let stand 24 hours, nitrogen as nitrate	1.5
55 cubic centimeters water added, let stand 24 hours, nitrogen as nitrate	38.0
45 cubic centimeters water added, let stand 24 hours, nitrogen as nitrate	38.0

The addition of a small amount of chloroform to the soil, or heating after saturation with water to 125° C. for five minutes, prevented this change of nitrates in the case of all the soils examined.

As was to be expected, this denitrification took place equally as rapidly with nitrates added as with that naturally in the soil. In working on this phase of the question larger quantities of soil were used, usually 500 or 1,000 grams. A number of soils were studied from this standpoint, and in a number of different ways, but the statement of one case will probably be sufficient at present. One thousand grams of soil containing 15 parts of nitrogen as nitrate were placed in a glass percolator of such size that the soil was about 8 inches in depth, and after saturation with water was allowed to stand 24 hours. Three hundred cubic centimeters of water containing 1 gram of potassium nitrate was then added, the drainage caught, and the total nitrogen, nitrate, ammonia, and nitrites determined in aliquot portions. This was repeated, at intervals of 24 or 48 hours, until 1.42 grams of nitrogen as potassium nitrate had been added. The soil was then washed until the drainage was free from nitrate, the drainage being analyzed as before. The figures obtained were as follows:

	Grams.
Total nitrogen added as nitrate	1.42
Total nitrogen recovered in drainage	.56
Difference	.86

The total nitrogen recovered in the drainage was distributed as follows:

	Grams.
Recovered as nitrate	0.268
Recovered as ammonia	.257
Recovered as nitrite	.008
Recovered as other forms	.027

The difference between the amount of nitrogen added as nitrate, and the total nitrogen recovered, can be explained in one of two ways—either 0.86 gram of nitrogen as nitrate had been changed to free nitrogen and had escaped, or it had been fixed in the soil in some form

difficultly soluble, probably organic. Opposed to the first explanation is the fact that at no time while the soil was standing, or on the addition of the nitrate solution, was any evolution of gas observed, and as 0.86 gram of moist nitrogen measure 792.6 cubic centimeters at 30° C and 760 millimeters, it is not conceivable that even a small portion of this amount could escape as gas without detection. In support of the second explanation is the nitrogen content of the soil. The original soil contained nitrogen 0.987 per cent and moisture 16.65 per cent, which is equivalent to 1.184 per cent nitrogen in the moisture-free soil. The figures obtained from the wet soil in the percolator after treatment were nitrogen 0.64 per cent and moisture 49.30 per cent, which is equivalent to nitrogen in the moisture-free soil 1.262 per cent. The difference obtained from analyses of the soil 0.78 per cent nitrogen is reasonably near the difference between nitrogen added and nitrogen recovered, viz, 0.86 gram in 1,000 grams of soil or 0.086 per cent.

There is, of course, nothing new in the recognition of the phenomenon of denitrification. It has been generally recognized as taking place in soils, especially those rich in organic matter, when for any reason there was not free access of air, as in the presence of excess of water. Various substances such as fresh manure, straw, etc., have been stated as being important factors in the case. Several investigators have also pointed out that in some cases there are good grounds for the assumption that in this change of nitrates a portion is stored in the soil in a little soluble, probably organic form.

Most writers on the subject make the statement that under ordinary conditions of cultivation denitrification is not an important factor in the growing of crops. While this may be true, generally, there are certain phases of the situation in Hawaii, notably climatic conditions and irrigation practices, which, in view of the preliminary work outlined above, force the conclusion that it is an important question here. In most localities here where crops are grown depending on the rainfall alone, there are times when the soil is practically saturated with water for weeks at a time. Where irrigation is practiced, limited for the most part to cane growing, it has been shown by several workers here that the soil is practically at or near the saturation point throughout the irrigating season; conditions which, as shown, bring about the denitrification of nitrate present or added to the soil. It has for a long time been accepted as axiomatic, especially by the planters here, that heavy rains or excessive amounts of irrigation water wash all nitrates out of the soil unchanged. This the work outlined above has demonstrated to be a mistake. For instance, in the experiment with 1,000 grams of soil noted above, the amount of nitrate added was equivalent to 15 tons of nitrate of potash per acre, using the weight of soil to the depth of 8 inches as the basis of calculation. But after the addition of

this excessive amount of nitrate, when the soil was washed continuously for about one month until no nitrate was contained in the drainage, only 18 per cent of the nitrate added was recovered.

While the samples of soil examined in this work have not been numerous, extreme types have been included from different islands, and the data obtained are sufficient to warrant the assertion that a widespread characteristic of Hawaiian soils is that when they are at or near the saturation point with respect to water, there is a change of nitrates and an apparent fixation of a portion of the nitric nitrogen in a form not easily soluble.

In this connection the question naturally arises: If a portion of the nitric nitrogen is fixed in the soil, in what form is it; and is it, or does it become, available for plant growth? A study of this question and a further study of the factors influencing the change will be carried on during the coming year.

On the completion of the new laboratory work was resumed on the study of the constitution of the nitrogenous compounds in Hawaiian soils. The considerations which led to taking up this work have been stated in the last report. It was decided to work on a soil or soils, fairly high in nitrogen, for the obvions reason that smaller quantities of soil would have to be handled to obtain amounts of nitrogenous bodies sufficient for identification; and also for the reason that the majority of soils, especially on Hawaii, suitable or available for crops other than cane are of this nature.

The work done has, for the most part, been on soil from one locality, viz, Pohakea, Hawaii, where this station is experimenting with tobacco. Along certain lines the work has been carried on with other soils, but the data from these is as yet fragmentary, and the results given below apply to the single soil mentioned above. Mechanical and partial chemical analyses of this soil have been published in Press Bulletin No. 12 of this station and are as follows:

Analysis of Pohakea soil.

Mechanical analysis, soil dried at 100° C.	Per cent.	Chemical analysis.	Per cent.
Combined water and organic	35.935	Water	19.540
Fine gravel 1–2 mm	16.511	Organic and combined water	28.360
Coarse sand 1–0.5 mm	11.337	Insoluble	19.320
Medium sand 0.5–0.25 mm	6.716	Fe_2O_3 iron and alumina	28.797
Fine sand 0.25–0.1 mm	14.002	Al_2O_3	
Very fine sand 0.1–0.05 mm	8.339	CaO lime	.200
Silt 0.05–0.0005 mm	5.848	MgO magnesia	.631
Clay 0.005–0.0001 mm	.940	SO_3 sulphuric acid	.343
		P_2O_5 phosphoric acid	.703
		K_2O potash	.077
		Nitrogen total	.728
		Humus total	12.470
		Humic nitrogen	.560
		Nitrogen in humus	4.490

The chemical analysis was made by the official method on soil which had passed a 0.5-millimeter sieve.

The work outlined below, however, was all done with soil which had passed a 1-millimeter sieve, the nitrogen content of which was higher, viz, 0.868 per cent. Nitrogen determinations were made by the Gunning method, without modification to include nitrates, and it is assumed that the small amount of nitrate present, 15 to 20 parts per million, does not enter as a factor at all. Throughout, percentage of nitrogen is calculated on the basis of air-dried soil, e. g., in the first example given below, total nitrogen in drainage 0.005 per cent means 0.005 gram of nitrogen from 100 grams of soil.

Despite the relatively large amount of nitrogen present, its extremely insoluble condition is shown by the following figures:

1. 1,000 grams of soil placed in a glass percolator; washed with 6,000 cubic centimeters water in portions of 200 cubic centimeters. Total nitrogen in drainage, 0.005 per cent.

2. 10 grams of soil boiled with 100 cubic centimeters water 1 hour, filtered and washed to 500 cubic centimeters. Total nitrogen in filtrate, 0.022 per cent.

3. 10 grams of soil treated in the cold with 100 cubic centimeters of 12 per cent hydrochloric acid, for 1 hour, filtered and washed with 200 cubic centimeters acid, and then with water to 500 cubic centimeters. Total nitrogen in filtrate, 0.002 per cent.

4. The residue from the treatment above was heated for 1 hour with 100 cubic centimeters water at 125° C.; filtered and washed to 500 cubic centimeters. Total nitrogen in filtrate, 0.042 per cent.

5. 10 grams of soil shaken for 2 hours with 100 cubic centimeters 95 per cent alcohol, washed with 200 cubic centimeters alcohol. Total nitrogen in filtrate, none.

6. 10 grams of soil shaken for 2 hours with 100 cubic centimeters 10 per cent salt solution, filtered, and washed free of chlorids. Total nitrogen in filtrate, 0.006 per cent.

7. 10 grams of soil heated for 3 hours with 100 cubic centimeters water at 125° C., filtered, and washed to 500 cubic centimeters. Total nitrogen in filtrate, 0.050 per cent.

Hot acids and alkalis had a pronounced solvent action, as shown by the following figures:

1. 10 grams of soil boiled for 7 hours under a reflux condenser with 100 cubic centimeters of 12 per cent hydrochloric acid, filtered, and washed free from acid. Total nitrogen in filtrate, 0.623 per cent.

2. The insoluble portion from the above treatment was digested (boiled) for 5 hours with 100 cubic centimeters of 12 per cent sulphuric acid, filtered, and washed free from acid. Total nitrogen in filtrate, 0.112 per cent, leaving 0.133 per cent insoluble after two digestions with acid.

3. 5 grams of soil were digested with 100 cubic centimeters of water and 10 cubic centimeters saturated solution of caustic potash for 1 hour, filtered and washed. Total nitrogen in filtrate, 0.728 per cent.

After these preliminary tests of solubility and behavior with reagents the following somewhat hit or miss experiments were made with the

hope of having some light thrown on probable constitution of the nitrogenous bodies present:

1. 10 grams of soil were digested with 100 cubic centimeters of acid pepsin for 12 hours at 40° C., filtered and washed. Total nitrogen dissolved, 0.076 per cent.

2. 5 grams of soil treated with cupric hydrate according to the official method for albuminoid nitrogen gave total nitrogen insoluble 0.851, or 0.011 per cent soluble.

3. 10 grams of soil boiled for 30 minutes with 2 grams of permanganate of potash and 125 cubic centimeters water; filtered and washed. Total nitrogen insoluble, 0.352 per cent, or 0.516 per cent soluble in neutral permanganate.

About the only positive information obtained from the above was the fact that a portion of the insoluble nitrogen could be oxidized to a soluble form by neutral permanganate. By repeating the digestion with an excess of permanganate the amount remaining insoluble was 0.229, or 0.539 per cent soluble.

By the combined action of permanganate and alkali a considerable portion of the nitrogen was set free as ammonia, e. g., 5 grams of soil on distillation with 1.6 grams permanganate, 1.5 grams caustic soda and 100 cubic centimeters water, gave nitrogen as ammonia 0.162 per cent, and on repeating the distillation as above with 10 grams permanganate, the nitrogen set free as ammonia was 0.308 per cent.

That in the first case above the nitrogen set free as ammonia, viz, 0.162 per cent, was due chiefly to the action of the alkali was shown as follows: 5 grams of soil on distillation with 1.5 grams caustic soda and 100 cubic centimeters water gave nitrogen set free as ammonia 0.154 per cent.

The amount of nitrogen present in the soil as ammonia determined by distillation with excess of magnesia was found to be 0.007 per cent. By using excess of milk of lime instead of magnesia distilling in a current of steam gave nitrogen as ammonia 0.035 per cent and distillation by direct heat 0.053 per cent.

The ready solubility of portion of the nitrogen in boiling acids seemed to promise some information, and solutions so obtained were treated by the method proposed by Osborne and Harris.[a] By this method, which in its turn is a modification of a method proposed by Hausmann,[b] the decomposition products which result from boiling protein bodies with acids are classified. The method, briefly, is freeing the solution from excess of acid by evaporation; determination of the nitrogen present as ammonia by distillation with magnesia; filtering from the magnesia precipitate; determination of the nitrogen in the magnesia precipitate, the basic nitrogen in the filtrate by precipitation with phosphotungstic acid, and the nonbasic nitrogen by difference.

---

[a] Jour. Amer. Chem. Soc., 22 (1905), p. 323.

[b] Ztschr. Physiol. Chem., 27, p. 92.

In the application of this method to soils 12 per cent acid was used instead of 20 per cent, as used by Osborne and Harris.

As stated above, boiling 10 grams of soil with 100 cubic centimeters of 12 per cent hydrochloric acid for seven hours gave 0.623 per cent nitrogen in solution; and treatment of the insoluble residue for five hours with 100 cubic centimeters 12 per cent sulphuric acid gave further soluble nitrogen 0.112 per cent. Treatment of the solutions so obtained by the method stated gave the following figures:

Forms of nitrogen in acid extracts.

	Per cent.
Hydrochloric acid solution:	
Nitrogen as ammonia	0.119
Nitrogen in magnesia precipitate	.280
Basic nitrogen	.140
Nonbasic nitrogen	.084
Total nitrogen in solution	.623
Sulphuric acid solution:	
Nitrogen as ammonia	None.
Nitrogen in magnesia precipitate	.105
Basic nitrogen	.005
Nonbasic nitrogen	.002
Total nitrogen in solution	.112

In comparing these figures with those obtained by Osborne and Harris working on pure protein bodies, the most striking point is the large amount of nitrogen contained in the magnesia precipitate. In the case of protein bodies it does not exceed 4 per cent of the total nitrogen and in most cases is very much less; but in the soil solutions it amounts to 45.2 per cent of the total in the hydrochloric acid solution and 93.7 per cent of total in sulphuric acid solution. Taking both solutions, we have total nitrogen in solution 0.735 per cent; nitrogen in magnesia precipitate 0.385 per cent, or 52.3 per cent of total.

This method has been applied to a number of soils with the same general result. It has also been found that increasing the time of boiling above two hours gave but slight increase in the amount of nitrogen dissolved. For example, in one case the difference between two hours and fourteen hours was 0.080 per cent, and the amount of nitrogen in the magnesia precipitate was in each case practically the same.

It seems a legitimate conclusion from this work that in the soil nitrogen which is soluble in boiling acids a portion, approximately 50 per cent, is in a form unlike, for the most part, the products of decomposition of protein bodies with acids.

Practically the same result has been obtained by using barium hydrate instead of magnesia. In a method proposed by Kossel and

Kutscher[a] for the separation of certain bodies resulting from the decomposition of protein with acids barium hydrate is used in this way. The amounts of nitrogen in the barium precipitate by this method when working on protein bodies is small, and the authors speak of it as humus nitrogen. Considering the small amounts involved and the fact that the method was applied in the study of other bodies, the authors are probably justified in using this vague term. In the case of a soil solution, however, containing 50 per cent of so-called humus nitrogen, such designation is very unsatisfactory since it conveys little or no information as to the nature of the body or bodies so named.

Along this line, then, a study of the nature of the nitrogen compound or compounds contained in the magnesia precipitate from acid solutions is the present stage of the work.

Approaching the nitrogen problem from another standpoint, some work has been done which may be outlined as follows:

All Hawaiian soils rich in nitrogen which have so far been examined give on dry distillation an alkaline distillate containing ammonia. In many cases the smell of ammonia on simple ignition in an open crucible is very pronounced.

The alkalinity of this distillate has been determined in a number of cases. The distillation was carried on first at a gentle heat and finally raised to a red heat, the distillate being collected in a known volume of standard acid. In the case of the Pohakea soil, assuming the alkalinity to be due to ammonia, it was found to be equivalent to 0.168 per cent nitrogen. The total nitrogen in the distillate was 0.145 per cent. It is interesting at this point to compare the ammonia actually in the soil as found by distillation with magnesia, 0.007 per cent, and also the ammonia derived from the acid solution, 0.119 per cent.

In addition to ammonia this distillate contains pyridin and some of its homologues not yet identified. The proportion of the alkalinity due to ammonia and that due to the pyridins has of course not yet been determined.

Generally speaking, pyridin is formed on the dry distillation of nitrogenous carbon compounds and as derived in this way is found in coal tar, tar from shales, peat, and in bone oil. Richter[b] says: "Its presence in bone oil is due to the reciprocal action of fats and substances containing ammonia (albumins), the acrolein arising from the first probably condensing with the ammonia to form pyridins. Bone glue free from fats does not yield pyridin bases, but mainly pyrrols."

---

[a] Ztschr. Physiol. Chem., 30 (1900), p. 166.

[b] Organic Chemistry, vol. 11, p. 528.

As the fat in this soil was found to be only 0.005 per cent, it does not seem likely that the pyridin formed was due to the formation of the pyridin ring by condensation, but rather that it exists already in some form in the soil.

Having in mind the light which has been thrown on the constitution of complex pyridin compounds by oxidation processes, oxidation of the soil by neutral and alkaline permanganate has been tried, and, while no very definite results have been obtained, enough has been accomplished to warrant continuing the work along this line. The action of alkaline permanganate on these soils is very energetic, and large containers are necessary to operate on quite small quantities of soil without loss.

The operation as carried on, without detailing unimportant variations, has been as follows: Permanganate, in small quantities at a time, was added to the soil suspended in water or alkaline solution, gentle heat being applied. When the addition of permanganate produced no further action, the manganese dioxid was filtered off, the filtrate neutralized with nitric acid, filtered, and the filtrate treated in various ways to recover oxidation products. This solution gives precipitates with lead, mercury, and silver salts, with cupric acetate in the cold and a further precipitate on heating. When the permanganate had been strongly alkaline there was obtained by decomposition of these precipitates with hydrogen sulphid a residue mostly crystalline, consisting for the most part of oxalic acid. By fractional crystallization and treatment with different solvents there has been obtained from this residue small quantities of a crystalline body giving pyridin on ignition with lime and the red color with ferrous sulphate characteristic of several of the pyridin carboxylic acids. The production of a relatively large amount of oxalic acid by the oxidation of the carbonaceous matter in the soil by the action of the permanganate is a serious obstacle in working along this line.

When the oxidation is carried on with neutral permanganate, or when the process in alkaline solution is not carried to completion, there was obtained by the same procedure a dark red or brown, apparently amorphous body, which gave pyridin on ignition with lime. This, apparently, is the body from which on further oxidation the pyridin carboxylic acid is formed.

At this stage this line of the work stands at present.

FUTURE WORK.

Throughout the foregoing report enough work has been outlined for some time to come. The fodder analyses and research work will be carried on along the lines indicated.

Miscellaneous work will probably continue to come in, but the only thing of this nature in view at present is the determination of the value

of bananas and pineapple waste for the production of alcohol. Banana growers, especially on Hawaii, have had difficulty in securing proper transportation for their bananas, and at all times have some small or inferior bunches which are not salable. It has been thought that it might be profitable to utilize such inferior fruit, or fruit which could not be shipped, in the manufacture of alcohol.

In the canning of pineapples there is a large amount of waste, peelings and cores amounting to about 40 per cent of the weight of the fruit. At present no use is made of this waste, and it seems too large in amount not to be of some value.

REPORT OF THE ENTOMOLOGIST.

By D. L. Van Dine.

INTRODUCTION.

Necessary additions have been made during the year to the office furniture and laboratory equipment. The records of the office are kept on card indexes, according to modern systems on the mainland, but modified to meet the requirements of one working without clerical or other assistance. Many additions have been made to the entomological library, a catalogue of which has been prepared. The correspondence continues to occupy a considerable portion of the time of the entomologist, but much time is being saved by his being able to place some of the information requested into the hands of the correspondents through the various entomological publications of the station.

Acknowledgment is made for many courtesies from other workers, and especially for the direct assistance given in the determination of specimens and for other information by Dr. L. O. Howard and other experts of the Bureau of Entomology of the U. S. Department of Agriculture.

ENTOMOLOGICAL ORGANIZATIONS IN HAWAII.

The past year has been an important one in the history of the economic entomology of the Hawaiian Islands. During this interval the Territorial government has organized and equipped a division of entomology, under the newly formed board of commissioners of agriculture and forestry, for quarantine and inspection and the introduction of the parasitic and predaceous enemies of insect pests. This department of the Territorial board supplants the office of the Territorial entomologist created by the provisional government of the Hawaiian Islands under the commissioner of agriculture and forestry in 1893, to which office Mr. Albert Koebele was appointed. On May 18, 1903, immediately after the formation of the newly appointed board of commissioners, Mr. Koebele was made superintendent of the

division of entomology, with Mr. R. C. L. Perkins as assistant superintendent and Messrs. G. W. Kirkaldy and F. W. Terry as assistants.

During the summer of 1904 the Hawaiian Sugar Planters' Association organized on a still more elaborate scale a division of entomology in their experiment station, Mr. R. C. L. Perkins resigning from the Territorial department to become director of the division of entomology in the Sugar Planters' station, with Messrs. Kirkaldy and Terry as assistants. Mr. Koebele, because of his special duties in the collection and introduction of the parasitic and predaceous enemies of injurious insects from abroad, also resigned as superintendent of the Territorial division of entomology. The board of commissioners of agriculture and forestry appointed Mr. Alexander Craw, formerly deputy commissioner of horticulture of California and State quarantine officer, as superintendent of entomology, with Mr. Koebele as consulting entomologist. Messrs. Koebele and Craw, are also consulting entomologists of the Sugar Planters' experiment station. The Sugar Planters' Association further appointed Mr. Otto H. Swezey as assistant entomologist. The board of commissioners of agriculture and forestry, to complete their staff, appointed Mr. Jacob Kotinsky as assistant entomologist, Mr. C. J. Austin, inspector's assistant, and the following "honorary entomological inspectors" for the principal ports of the islands outside of Honolulu: Mr. E. A. Frasier, Mahukona, island of Hawaii; Mr. J. Castle Ridgeway, Hilo, island of Hawaii; Mr. W. O. Aiken, Kahului, island of Maui; and Mr. W. D. McBryde, Koloa, island of Kauai.

The present official entomological organizations in Hawaii in the order of their creation are:

Department of Entomology, Hawaii Agricultural Experiment Station, under the supervision of the Office of Experiment Stations, U. S. Department of Agriculture, Honolulu, Hawaii.

Organized July 1, 1902. Lines of work: Collection and study of the insect pests of Hawaii in their relation to the agricultural development of the Territory and the publication of information on the life history, development, habits, and injury, with the known cultural, natural, and active remedies applicable for their control.

Staff: D. L. Van Dine, entomologist.

Division of Entomology, Board of Commissioners of Agriculture and Forestry of the Territory of Hawaii, Honolulu, Hawaii.

Organized May 18, 1903. Lines of work: "All matters relating to the exclusion or eradication of insects, scales, blights, and diseases injurious, or liable to become injurious, to trees, plants, or other vegetation of value, and relating to the quarantine, inspection, disinfection, exclusion or destruction of any plant, article, or substance injurious, or liable to become injurious, to trees, plants, or other vegeta-

tion of value mentioned in or coming within the scope of this act, and of such other matters as the board may from time to time direct."

Staff: Alexander Craw, superintendent and inspector.
A. Koebele, consulting entomologist.
Jacob Kotinsky, assistant entomologist.
C. J. Austin, inspector's assistant.

Division of Entomology, Experiment Station of the Hawaiian Sugar Planters' Association, Honolulu, Hawaii.

Organized August, 1904. Lines of work: Study of the insect pests of sugar cane, and the collection, introduction, and distribution of the parasitic and predaceous enemies of the insect pests of sugar cane.

Staff: R. C. L. Perkins, director.
A. Koebele, consulting entomologist.
Alexander Craw, consulting entomologist.
G. W. Kirkaldy, assistant entomologist.
F. W. Terry, assistant entomologist.
Otto H. Swezey, assistant entomologist.

BEE KEEPING.

The bee keeping industry in the Hawaiian Islands represents an investment of approximately $150,000. With the exception of a few Japanese who are engaged in the work individually on a small scale and certain others who produce comb honey for local consumption, the industry is in the hands of three corporations, one of which equals in production the combined product of the other two. It is apparent that with the completion of the plans of expansion now under way by these corporations the next year or so will see the various honey producing localities of the islands well covered and the limit of production attained. (Pl. II, figs. 1 and 2.) This is of course on the present basis of production. The entomologist believes that the local consumption of this product could be greatly increased and in the local market a small producer could easily compete with a large corporation where the freight rates and amount produced would not permit competition in the markets of the mainland or Europe. Again, many small producers could organize an association and grade and market their honey in bulk with equal advantage in comparison to large shipments of a single concern. Although under corporation management the honey industry will in the near future reach its limit, there is still room under proper management for small producers, depending only in part on honey for their income and perhaps doing a large share of the manipulation of the apiary at odd hours of their time, to enter the field and obtain a fair return for their labor. As with silk culture, bee keeping could be carried on in certain localities as a side issue and, by organizing the marketing, prove a source of income.

FIG. 1.—APIARY AT PEARL CITY, OAHU, UNDER ALGEROBA TREES.

FIG. 2.—JAPANESE HELPER ROBBING HIVES.

Algeroba, native "keawe," *Prosopis juliflora*. This tree is the most abundant and principal bee plant of the islands, and the principal apiaries are situated along the coast of the various islands in the shelter of the algeroba forests.

Various species of Acacia—wattle, koa, etc.

Sisal (*Agave sisalana*).

Alligator pear (*Persea gratissima*).

Banana (*Musa* spp.).

Various species of Eucalyptus.

Guava (*Psidium* spp.).

Lantana.

Various species of Citrus—orange, lemon, lime, etc.

Loquat (*Eriobotrya japonica*).

Various species of cucurbits.

Rose apple (*Eugenia jambos*).

Sugar cane (*Saccharum officinarum*).

Tamarind (*Tamarindus indica*).

Tobacco (*Nicotiana tabacum*).

Catalpa speciosa, a good honey tree introduced some three years ago by Mr. Jared G. Smith, special agent in charge of this station.

Ilima (*Sida cordifolia*).

Palms.

This station has successfully introduced the Italian bee into the Philippines during the past year and will undertake to import certain bees into these islands during 1906.

SILK CULTURE.

The production of raw silk is essentially a "home" occupation—a work for women and children, and men at idle seasons of the year. The labor requires a certain amount of training, but only such as is easily acquired by a season's work or so. It would seem that this industry is well suited to the conditions in these islands. The climate in some localities is even and cool, the mulberry thrives over the entire group of islands, and in the large families of Japanese and Portuguese we have people who could increase the income of the family and at the same time add to the revenue of the country. The cultivation of silkworms by the families of plantation laborers on lands above the cane would lead to more stable labor conditions and attach the laborers more closely to the country. It is an industry likewise that might well be considered in conjunction with coffee growing. It will evidently be most desirable to import the eggs from California, and the work, if undertaken, should be so organized in the various communities that some one person is responsible for the introduction of

the eggs in cold storage and their artificial incubation, since the warmer temperature of these islands will not permit normal hatchings under natural conditions.

Two breeding experiments have been conducted at the station, one under natural conditions and the other with eggs imported in cold storage and kept on ice until ready for hatching. The results of these experiments are given in the following tables and illustrate in the first instance the variability of hatching and development under natural conditions and in the second experiment more encouraging results under artificial conditions.

The introduction of the eggs and their hatching by some one person understanding their proper manipulation and having the distribution of the worms to the individual growers would prevent a repetition of the failure several persons have met with who have sought to establish the industry in Hawaii. After further work a more careful and detailed consideration of the question will be published by this station.

In the first table the silkworm eggs were received by mail from Tokyo, Japan, whence they were forwarded December 12, 1904. In the second table the eggs were forwarded from Washington, D. C., in cold storage March 6, 1905, and removed from the ice April 1, 1905.

Variable hatching and development of silkworm eggs shipped under normal conditions.

Date of hatching.	Molting periods.				Beginning of spinning.	Total life period.
	First.	Second.	Third.	Fourth.		
						Days.
Jan. 1	Jan. 7	Jan. 8	Jan. 26	Feb. 2	Feb. 12	42
Jan. 2–5	Jan. 14	Jan. 20	Jan. 27	Feb. 3	Feb. 13	39
Jan. 6–9	Jan. 18	Jan. 23	Jan. 31	Feb. 7	Feb. 16	38
Jan. 10–12	....do...	Jan. 26	Feb. 3	Feb. 10	Feb. 19	38
Jan. 13–16	Jan. 20	Jan. 27	Feb. 7	Feb. 13	Feb. 22	37
Jan. 17–20	Jan. 24	Jan. 31	Feb. 9	Feb. 16	Feb. 25	36

On January 23 the eggs were hatching very slowly, and fully one-third were thrown away. The mean maximum temperature from January 1 to February 25 was 78.9° and the minimum 62.7° F. The sky was almost uniformly clear during the whole time.

Uniform hatching and development of silkworm eggs shipped in cold storage.

Date of hatching.	Molting periods.				Beginning of spinning.	Total life period.	Weight of cocoons.
	First.	Second.	Third.	Fourth.			
						Days.	*Lbs. ozs.*
Apr. 2	Apr. 7	Apr. 13	Apr. 19	Apr. 26	May 6	34	10 3
Apr. 3	Apr. 8	Apr. 14	Apr. 20	Apr. 28	May 7	34	14 10
Apr. 4	Apr. 9	Apr. 15	Apr. 21	Apr. 29	May 9	35	12 15

The mean maximum temperature during the growing period was 78.84° and the minimum was 66° F. The weather was partly cloudy most of the time. The silkworms were killed with fumes of carbon

bisulphid, and the weight of the cocoons after drying until August 1 was 18 pounds 6 ounces.

The times of feeding and weight of mulberry leaves consumed are shown in the accompanying table:

Time of feeding and food consumed by silkworms hatched from one-third ounce of eggs.

Time of feeding.	Times fed per day.	Amount consumed in 24 hours.	Time of feeding.	Times fed per day.	Amount consumed in 24 hours.
		Lbs. ozs.			*Lbs. ozs.*
Apr. 2	7	0 2	Apr. 23	6	20 0
Apr. 3	7	0 5	Apr. 24	6	29 0
Apr. 4	7	0 8	Apr. 25	6	26 0
Apr. 5	7	0 15	Apr. 26	6	25 0
Apr. 6	7	0 9	Apr. 27	6	17 8
Apr. 7	7	1 6	Apr. 28	6	15 0
Apr. 8	7	1 2	Apr. 29	6	22 0
Apr. 9	7	1 5	Apr. 30	6	28 0
Apr. 10	7	2 4	May 1	5	47 0
Apr. 11	7	4 0	May 2	5	51 0
Apr. 12	7	6 8	May 3	5	53 0
Apr. 13	7	5 6	May 4	5	63 0
Apr. 14	7	4 8	May 5	5	60 0
Apr. 15	6	3 0	May 6	5	58 0
Apr. 16	6	6 4	May 7	5	43 0
Apr. 17	6	9 8	May 8	5	22 8
Apr. 18	6	14 0	May 9	5	15 8
Apr. 19	6	14 8	May 10	5	7 8
Apr. 20	6	8 0	May 11	5	1 8
Apr. 21	6	6 0			
Apr. 22	6	13 0	Total		707 10

MOSQUITOES.

Active work in mosquito control on the part of the Citizens' Mosquito Committee ceased last year, and the subject was turned over to the Territorial board of health. An item of $7,200 to conduct the campaign was proposed for the regular appropriation bill of the board of health for two years, but this did not receive the indorsement of the administration, and the board has relied on money from private sources to defray the expenses of the work. It has been demonstrated thoroughly that it is possible to control the nuisance, and constant headway is being made in bringing householders to a realization of their responsibility in the matter of the mosquitoes infesting their houses. The citizens' committee found it impossible to continue the campaign on the basis of private subscriptions, since a few were paying for a benefit to all, and it was generally thought that since the demonstration had proved successful, the work should become a function of the government.

In the question of breeding places, there are many natural ones existent about taro patches, rice fields, and irrigation ditches that can not, without great expense, be treated directly. These places are not responsible for any large percentage of the mosquitoes in the towns and cities. However, places situated near by do receive their mosquitoes from these sources and they call for attention. It is proposed to stock these places with certain mosquito-eating fish. Aside from a

few gobies, locally known as "oopu," the gold fish are the only fish in Hawaii that are especially fond of the mosquito wriggler. An attempt will be made to introduce into the islands fish that are special mosquito feeders.

INTRODUCTION OF MOSQUITO-EATING FISH.

Several years ago the entomologist concluded that the absence of special mosquito-feeding fish was responsible for the numbers of mosquitoes which must be credited as breeding in taro patches, rice fields, irrigation ditches, lily ponds, and especially the abandoned rice and taro fields. The following letter, self-explanatory, was addressed to Doctor Jordan:

JANUARY 9, 1903.

DR. DAVID STARR JORDAN,
President Leland Stanford, jr., University,
Stanford University, Cal.

MY DEAR DOCTOR JORDAN: I am working just now on the mosquito problem here. In regard to the natural enemies of this pest, I would like to find out what fish or fishes we have here in the small ponds, streams, taro patches, and rice fields (the natural breeding places of the mosquito) which feed to any extent on the larvæ and pupæ. The common "gold fish" occurs here in large numbers, and, I believe, feeds to a great extent on the young mosquitoes. I have observed a single fish eat nearly two hundred larvæ during two days' confinement in an aquarium. Other gold fish taken from small pools contained the remains of larvæ in their stomachs.

Doctor Howard speaks of the common sunfish and one or two species of "top minnows" as especially active in the destruction of mosquito larvæ and pupæ. Would it not be feasible for us to attempt to introduce some of these beneficial species to breed in places where it is undesirable to drain or use the oil treatment?

Very sincerely, yours,

D. L. VAN DINE.

Doctor Jordan replied as follows:

STANFORD UNIVERSITY, CAL., *January 21, 1903.*

MR. D. L. VAN DINE,
Experiment Station, Honolulu, Hawaii.

DEAR SIR: The only fishes that you have which feed upon mosquitoes in the small ponds are the different kinds of gobies, locally known as "oopu," and the gold fish. The different species of oopu are found in all the streams, but whether they feed on the larvæ or not must be determined by dissection.

The top minnows are entirely unrepresented in Hawaii. They are very easily transported, being extremely hardy. There are, however, none of them in California, and they would have to be brought either from the Mississippi Valley or from Mexico. The best species for your purpose could be found in the streams of central Mexico, but it would be a little costly to send a man down to get them. Next to these I would recommend trying the Gulf States or Florida. These species belong to the family of Pœciliidæ, and there are many species, nearly all American. The single Japanese species is common in rice ditches in the extreme south of Japan, and probably feeds on larvæ.

Very truly, yours,

DAVID S. JORDAN.

While Doctor Jordan was in Honolulu recently the subject was further discussed, and he offered to send an expert of Stanford Uni-

versity to the southern United States to collect representatives of the family of top minnows and introduce them into Hawaii, providing the Territory would furnish the money for the expenses of the trip. The proposal was submitted to the consideration of the governor by Dr. C. B. Cooper, as chairman of the legislative committee of the Citizens' Mosquito Committee, and the writer, as chairman of the advisory committee. This action led to the following communication to the governor on the subject:

HONOLULU, HAWAII, *March 12, 1905.*

HON. GEORGE R. CARTER,
Governor of the Territory of Hawaii, Honolulu.

SIR: Dr. David Starr Jordan, of Stanford University, having offered to send an expert of that institution to collect for these islands certain fish of the Southern States and Mexico, at present entirely unrepresented here, that feed upon the larvæ of mosquitoes, providing the Territory pay the expenses of such trip, the undersigned, at your request, beg to say that for the expense of such a trip a sum of not less than $1,500 should be provided. We suggest that, if appropriated for the above purpose, this sum, or as much thereof as is necessary, be spent under the direction of the board of health, since the president of that department of the government is the chairman of the Citizens' Mosquito Committee.

Very respectfully, yours

CHAS. B. COOPER, M. D.,
Chairman Legislative Committee.
D. L. VAN DINE,
Chairman Advisory Committee.
Representing the Citizens' Mosquito Committee of Honolulu.

At the opportune time this communication was transmitted to the legislature with the following indorsement:

(Letter of May 10, 1905, from Governor Carter to the legislature.)

To the Legislature of the Territory of Hawaii:

Herewith, I transmit for your consideration copy of a letter of March 12, containing a proposal made by Dr. David Starr Jordan, of Stanford University, to provide an expert, with the necessary apparatus, to undertake the importation into these islands of a certain small and vigorous fish found in Mexico that feeds on the larvæ of the mosquito, provided the Territory simply pays the expense of such an undertaking.

You are aware that the only fish we have at present exclusively occupying our fresh waters is a species of mud fish, commonly known as the oopu, and the gold fish. You are also aware that there is known to exist here the species of mosquito which carries the germs of yellow fever, which, fortunately for us, has not as yet been inoculated, but with the completion of the Panama Canal it will only be a question of time before cases of this or some other disease will reach this port. Every interest in the Territory would be advanced if this mosquito could in some way be entirely eradicated, or at least reduced to the smallest possible number.

G. R. CARTER, *Governor.*

The subject was referred to the health committee of the house at once, and the writer went before this committee and laid the question fully before them. The committee report favorably, and the item

($1,500) was included under general expenses of the Territorial board of health, and reads, "Expenses, importation of fish for destruction of mosquitoes, $1,500."

In accordance with the following letter, Doctor Jordan selected Mr. Alvin Seale to undertake this work:

STANFORD UNIVERSITY, CAL., *April 18, 1905.*

Mr. D. L. VAN DINE,

United States Experiment Station, Honolulu, Hawaii.

DEAR SIR: The best place to collect the fishes which you want would doubtless be in Louisiana. It would probably take no longer time to bring them from there than from other places nearer. Perhaps an equally good place would be Tampico, on the edge of Mexico. You understand that this would necessarily be an experiment. These little fishes feed freely on mosquitoes. Some live in brackish water, some in fresh water, and all of them are very hardy. But no one has ever yet tried to transplant any of them, and the whole thing might turn out, for some reason or other, to be a failure. Especially one would need to experiment on feeding the little fishes during their transportation. The genera which I would recommend are Mollienesia, Adinia, Gambusia, and Fundulus. Some of these are viviparous, others lay eggs. Whoever undertakes this should give a good deal of attention to the question of feeding the little fishes, and for this purpose perhaps a tank breeding mosquitoes would be as good as anything. The best time to undertake it would be about the 1st of June. I will select some one as soon as I hear from you.

Very truly, yours, DAVID S. JORDAN.

A PARTIAL LIST OF THE INJURIOUS INSECTS OF HAWAII, PART 2.

(Continued from Report of the Office of Experiment Stations, 1904.)

CITRUS TREES.

On October 27, 1904, citrus twigs were collected by J. E. Higgins, Mountainview, Island of Hawaii, infested with purple scale (*Lepidosaphes beckii* Newm.). The scales were infected with a fungus disease reported to be *Microcera rectispora* Che. and Mass. by Mr. A. F. Woods, of the Bureau of Plant Industry, U. S. Department of Agriculture.

A barkbeetle (*Stephanoderes* sp.) was taken from the terminal twigs of orange trees at Kalihi, Honolulu. The trees were evidently suffering from the disease commonly known as "die-back."

ALLIGATOR PEAR OR AVOCADO.

Twigs were received from Hilo, Hawaii, infested with *Xyleborus immaturus* Blackburn.

The scale insect (*Phenacaspis eugeniæ* Mask.) was taken from the alligator pear in Honolulu.

BANANA.

Two scale insects (*Phenacaspis eugeniæ* Mask. and *Chrysomphalus ficus* Ashm.) were taken during the year on the leaves and fruit.

Chrysomphalus ficus was also taken from oleander, *Amelia* sp., and the fan-palm.

Phenacaspis eugeniæ Mask., on leaves and fruit; taken also from magnolia.

On July 5, 1905, Mr. J. E. Higgins handed the entomologist specimens of the seeds of mangoes infested with the larvæ and pupæ of a beetle. Two days later the entomologist visited a mango district in the vicinity of the place where Mr. Higgins found the infested fruit and obtained larvæ, pupæ, and adults of the same species. Duplicates of these forms were forwarded on July 11 to the Bureau of Entomology of the U. S. Department of Agriculture, and examined and reported upon by Mr. E. A. Schwarz under date of July 26. Mr. Schwarz gives the determination of the weevil as *Cryptorhynchus mangiferæ* Fab., originally described by Fabricius in 1774 and says further: "Its original home is uncertain, for since many years it has spread (no doubt through the agency of man) throughout the 'Oriental Region' from Madagascar through India, Ceylon, etc., to Java and other Malayan Islands. It probably occurs now also in many of the islands of the Pacific Ocean, although I fail to find any records. The species is not enumerated by Sharp from the Hawaiian Islands and is no doubt a recent introduction there. The weevil appears to be extremely injurious to mangoes, and accounts of its ravages are numerous."

Since the life cycle is passed within the seed, and the female, as is customary with the species of this family, deposits the egg in the food of the larva, the insect must have been introduced in fruit or seeds of the mango brought to the islands for propagation from India or possibly the Philippines. It is evident that the fruit is infested in the very early stages of its development, for the reason that there is no indication of the entrance to the seed of the larva through the seed husk. The work of the very young larva is indicated, and since no point of entrance is to be observed it would seem that the length of the life cycle of the insect is somewhat longer than the time of development of the fruit, as shown by the fact that seeds removed from matured mangoes contain the larval weevil.

In the first lot of mangoes examined it was estimated that about 60 per cent were infested—that is, out of 44 seeds examined 28 contained either the advanced larval, pupal, or adult stages. The next lot, examined six days later at the same place, resulted as follows: Sixteen seeds each were taken of the No. 9, the Chutney, and the common "Hawaiian" variety, and of the No. 9, 11 were good and 5 infested; of the Chutney 6 were good and 10 infested, and of the common variety 8 were good and 8 infested. The following varieties planted in seed beds were examined: Twelve seeds each of the Chutney and the No. 1 were selected at random, and of the former 10 were infested

and 2 were good, and of the latter 3 were infested and 9 were good. In both instances the Chutney shows the largest number of infested seeds.

SISAL.

Pseudolus longulus Boh. (family Calandridæ), boring in the pole of matured plants. Probably a native of the Hawaiian Islands.

Pseudococcus sp., a mealy bug, very abundant at the base of the inner leaves; preyed upon by the following ladybird beetles: *Coccinella repanda* Muls., *Cryptolæmus montrouzieri* Muls., *Scymnus ocellatus* Sharp, and *S. vividus* Sharp.

The black scale (*Saissetia oleæ* Bernard) on leaves, not abundant.

CASSAVA.

Pseudolus longulus Boh., boring in stalk. (See above.)

Lagocheirus araneiformis Linn. (family Cerambycidæ), boring in stalk; taken also from fig.

TARO.

A mole cricket (*Gryllotalpa africana*) is periodically abundant in some localities. It works on the root.

Aphis sp. (undetermined), abundant on leaves.

GARDEN PRODUCTS.

A leaf-miner (*Plutella maculipennis* Curtis), abundant in the leaves of cabbage. Parasitized by *Campoletis* (*Limneria*) *tibiator* Cress.

The tobacco flea-beetle (*Epitrix parvula* Fab.) was epidemic on tomatoes in one locality during the year.

OTHER HORTICULTURAL PLANTS.

Pseudococcus filamentosus Ckll., on hibiscus, Honolulu.

Saissetia hemisphærica Targ., on *Lawsonia alba* and sago palm, Kapiolani Park, Honolulu.

Dactylopius nipæ Mask. and *Coccus longulus* Doug. on sour sop (*Anona muricata*), Honolulu.

Pseudococcus (*Dactylopius*) *pseudonipæ* Ckll., from palm, Honolulu.

Mytilaspis pallida Green, from croton, Honolulu.

The Japanese rose beetle has been determined by Mr. E. A. Schwarz as *Adoretus umbrosus* Fab. var. *tenuimaculatus* Waterh.

Coccus hesperidum L., on *Ipomæa* sp., Pahala, Hawaii. Parasitized by *Coccophagus immaculatus* How.

Chrysomphalus dictyospermi Morg., on sago palm, Honolulu.

TOBACCO.

The tobacco hornworm (*Phlegethontius quinquemaculata* How.), from experimental field, Hamakua, island of Hawaii.

The Japanese rose beetle (*Adoretus umbrosus* Fab. var. *tenuimaculatus* Waterh.), injurious to young plants in seed beds.

The cigarette beetle (*Lasioderma serricorne* Fab.), infesting cigars, cigarettes, and many stored products.

STORED PRODUCTS.

The following beetles were found infesting fish guano and bone meal fertilizers in a storehouse in Honolulu: *Dermestes cadaverinus* Fab., *Lasioderma serricorne* Fab., and *Tribolium ferrugineum* Fab.

FOREST INSECTS.

Black wattle (*Acacia decurrens*):

Bruchus sp., probably a new species infesting seeds. Australian seeds purchased from a San Francisco firm.

Cyllene crinicornis Chevr. (family Cerambycidæ), abundant. Wide geographical distribution, recorded from Mexico, West Indies, Key West, Texas, etc.

Xytrocera globosa Olivier (family Cerambycidæ), abundant. Occurs also in Japan, Philippines, East Indies, Madagascar, Mauritius, and Java.

Ceresium simplex Gyll. (family Cerambycidæ), not abundant.

Sotenus setiger Sharp (family Cerambycidæ), not abundant. Probably a native of the islands.

Chalcolepidius erythroloma Candèze (family Elateridæ), not abundant. A native of Chile.

Stephanoderes sp. (family Scolytidæ), working in branches of felled trees.

Siphanta acuta Walk., a leaf hopper of the family Fulgoridæ, subfamily Flatinæ, locally known as the torpedo bug; abundant; preyed upon by *Œchalia griseus*.

Icerya purchasi Mask., periodically in evidence. Abundant also during the year on *Casuarina*. Reported as abundant on the island of Maui. Kept in check by its ladybird enemy, *Novius cardinalis* Muls.

The larva of an undescribed moth of the family Tineidæ is very abundant, working beneath the bark of dead or partly dead trees.

Algeroba (*Prosopis juliflora*):

Microcantha nutans Sharp (family Cerambycidæ), not abundant; taken also during the year from fig (*Ficus carica*).

Cyllene crinicornis Chevr. (family Cerambycidæ).

Bostrichus migrator Sharp (family Bostrichidæ); taken also from *Waltheria americana*.

Sinoxylon conigerum Gerst. (family Bostrichidæ). Very abundant in partly seasoned wood.

The bean weevil (*Bruchus obtectus* Say) infests the pods of algeroba to a great extent.

ENTOMOLOGY OF THE HAWAIIAN ISLANDS.

The islands comprising the Hawaiian group have offered peculiar conditions for the development of an endemic insect fauna. It is an insular territory of volcanic origin, the islands being separated by channels varying from 20 to 58 miles across, and the whole group over 2,000 miles from the nearest continent, the California coast. Although lying just within the Tropics, the climate is made semitropical by the prevailing northeast trade winds, giving an almost uniform temperature, the rainfall varying with exposure and altitude. The soils range in character from those capable of supporting a rank and abundant forest growth to those in process of formation from recent volcanic eruption. The islands, situated as they are at the "cross-roads" of the Pacific Ocean, have enjoyed an intimate commercial relation with nearly all the important countries of the world, and until tropical and certain temperate-zone countries have been more closely studied it will be uncertain to credit many of the species taken and described for the first time from Hawaii as endemic to the islands. The study of Hawaii's indigenous insects has become a difficult one, for the reason that the invasion of new plants and a new industrial people has caused the natural vegetation to give way to newer forms, or having been destroyed, has been supplanted by cultivated plants or its place left vacant. This of necessity has brought about the destruction of the endemic plant-feeding species of insects and their related parasitic and predaceous insect enemies, or confined them to the remnants of the Hawaiian vegetation found in mountainous districts, and in some instances almost inaccessible places.

To the Rev. Thomas Blackburn undoubtedly belongs the title "the father of Hawaiian entomology." During a residence of some six years in the islands (1877 to 1883) in connection with his profession Mr. Blackburn found time to devote to important work on the insects of the islands in general, and on beetles (Coleoptera) in particular. Not only was his the first important systematic collecting, but his keen appreciation of the rich field and his enthusiasm in obtaining representative material led to further work. As chaplain to the Bishop of the Church of England, Mr. Blackburn naturally referred his material to the scientific institutions of that country, where he possibly earlier had received his knowledge of the subject and the interest which led him to undertake the work. It thus came about that others than the scientists of the United States, under whose province the work would

seemingly more naturally have come, have given to us our present knowedge of the Hawaiian insect fauna.

To an American this is of course regrettable, but there is consolation in the fact that certain of the material has been referred to the specialists of our own country for monographic treatment. The regret is not that the work has been done, for the survey of the islands entomologically has been carefully and, in so far as the territory covered is concerned, thoroughly made. The person who has procured the major portion by far of the material upon which is based the present knowledge of Hawaii's fauna, especially in regard to the species peculiar to the islands, is Mr. R. C. L. Perkins, who for nearly ten years has been a persistent and untiring collector in the islands, working under the direction of The Royal Society of London for Promoting Natural Knowledge and the British Association for the Advancement of Science, assisted by the Bernice Pauahi Bishop Museum of Honolulu. The regret that American workers have not participated in the work is that, in the rich results obtained in a territory for many years closely related to and now a part of our own Government, we have seemingly been neglectful of our opportunities, and fail to receive a portion of the well-deserved credit falling to those who have accomplished the work.

The islands as regards plant growth may be divided into (1) the coastal plains and lower slopes of the mountains, devoted to the cultivation of sugar cane as the principal crop, with rice and taro secondary; (2) an area of considerable extent between the "cane lands" and the mountainous districts devoted to grazing on a large scale and the cultivation of coffee, pineapples, corn, potatoes, and other minor crops on a limited scale; (3) forest lands of the mountainous districts; and (4) lands devoid of vegetation comprising recent lava flows, and the areas above the forest belts of the higher mountains. The insects peculiar to the islands are confined in the main to the forest districts, and the lands described under the fourth class offer little of interest entomologically. Passing to a consideration of the economic entomology of the Territory we can see that with the disappearance of the natural vegetation and the natural insects their study is becoming more difficult and, from an economic standpoint, less important. On the other hand, with an increase of the area under cultivation, with the introduction of new plants, and with the commercial relations between other countries becoming more intimate, the study of the economic species is becoming more and more important. These economic species are mainly of foreign origin and many are of comparatively long standing, while others, more noticeable because of their varying work, are of recent introduction.

There is submitted herewith a partial bibliography of the systematic and economic entomology of the Hawaiian Islands.

A PARTIAL BIBLIOGRAPHY OF HAWAIIAN ENTOMOLOGY.

Compiled by D. L. Van Dine.

[Note.—The references marked with an asterisk (*) are in the entomological library of the station.]

SYSTEMATIC.

Alfken, J. D. *Megachile schauinslandi* n. sp. Eine neue Megachile-Art aus Honolulu. Ent. Nachr., 24 (1898), pp. 340, 341.

———. Die Xylocopa-Art der Hawaiian Islands. Ent. Nachr., 25 (1899), pp. 317, 318.

*———. Neue Orthopteren von Neu-Seeland und den Hawaiischen Inseln. Ergebnisse einer Reise nach dem Pacific (Schauinsland, 1896–97). Abhandl. Nat. Ver. Bremen, 17 (1901), No. 1, pp. 141–152.

*———. Beitrag zur Insectfauna der Hawaiischen und Neuseelandischen Inseln. Ergebnisse einer Reise nach dem Pacific (Schauinsland, 1896–97). Bremen, 1903.

*Ashmead, W. H. Hymenoptera parasitica. Fauna Hawaiiensis. Cambridge, 1901, vol. 1, pt. 3, pp. 277–364, pls. 2.

*Bailey, E. The flora and fauna of the Hawaiian Islands. Hawaiian Almanac and Annual for 1888. Honolulu, 1887, pp. 49–54.

Bigot, J. M. F. Dipteres nouveaux ou peu connus. 33e partie. Tachinidæ. Ann. Soc. Ent. France, 6. ser., 8 (1888), pp. 77–101.

Blackburn, T. Characters of a new genus and descriptions of a new species of Geodephaga from the Sandwich Islands, I. Ent. Mo. Mag., 14 (1877), pp. 142–148.

———. Characters of new genera and descriptions of new species of Geodephaga from the Hawaiian Islands, II. Ent. Mo. Mag., 15 (1878), pp. 119–123, 156–158.

———. Characters of new genera and descriptions of new species of Geodephaga from the Hawaiian Islands, III. Ent. Mo. Mag., 16 (1879), pp. 104–109.

———. Characters of new genera and descriptions of new species of Geodephaga from the Hawaiian Islands, IV. Ent. Mo. Mag., 16 (1880), pp. 226–229.

———, and Kirby, W. F. Notes on species of aculeate Hymenoptera occurring in the Hawaiian Islands. Ent. Mo. Mag., 17 (1880), pp. 85–89.

———. Descriptions of the larvæ of Hawaiian Lepidoptera. Ent. Mo. Mag., 19 (1882), pp. 55, 56.

———. Characters of new genera and descriptions of new species of Geodephaga from the Hawaiian Islands, V. Ent. Mo. Mag., 19 (1882), pp. 62–64.

*———. Hawaiian entomology. Hawaiian Almanac and Annual for 1882. Honolulu, 1881, pp. 58–61.

———. Notes on the Hawaiian Carabidæ. Ent. Mo. Mag., 21 (1884), pp. 25, 26.

———. Notes on Hawaiian Neuroptera with descriptions of new species. Ann. and Mag. Nat. Hist., 5. ser., 14 (1884), pp. 412–421.

*———, and Sharp, D. Memoirs on the Coleoptera of the Hawaiian Islands. Sci. Trans. Roy. Dublin Soc., 2. ser., 3 (1885), pp. 119–290, pl. 1.

*——— and Cameron, P. On the Hymenoptera of the Hawaiian Islands. Mem. Manchester Lit. and Phil. Soc., 3. ser., 10 (1885–86), pp. 194–245.

———. Notes on the Hemiptera of the Hawaiian Islands. Proc. Linn. Soc. New South Wales, 2. ser., 3 (1888), pp. 343–346.

Boisduval, J. A. Entomologie du voyage de l'Astrolabe. Paris, 1832–35.

*Bormans, A. de. Faune orthoptérologique des Iles Hawaii ou Sandwich. Ann. Mus. Genova, 18 (1882–83), pp. 438–448.

*Brunner von Wattenwyl, C. On the Orthoptera of the Sandwich Islands. Proc. Zool. Soc. London, 1895, pp. 891–897.

Burmeister, H. Meyen's Beiträge zur Zoologie, gesammelt auf einer Reise um die Erde. Coleoptera und Lepidoptera. Nova Acta Acad. Caes. Leop., 1834, vol. 16, sup. 1, pp. 219–284.

*Butler, A. G. On the Lepidoptera from the Hawaiian Islands. Trans. Ent. Soc. London, 1882, pp. 31–45.

Cameron, P. Notes on Hymenoptera with descriptions of new species. Trans. Ent. Soc. London, 1881, pp. 555–562.

———. Descriptions of new genera and species of Hymenoptera. Trans. Ent. Soc. London, 1883, pp. 187–193.

Cockerell, T. D. A. Notes on the geographical distribution of scale insects. Proc. U. S. Nat. Mus., 17 (1895), p. 621.

*———. Miscellaneous notes on Coccidæ. Canad. Ent., 27 (1895), p. 259.

———. A check list of the Coccidæ. Bul. Illinois State Lab. Nat. Hist., 4 (1896), pp. 318–339.

*———. The San José scale and its insect allies. U. S. Dept. Agr., Division of Entomology Bul. 6, tech. ser., 1897, p. 22.

———. Food plants of scale insects. Proc. U. S. Nat. Mus., 19 (1897), pp. 725–785.

———. The Coccidæ of the Sandwich Islands. Entomologist, 31 (1898), pp. 239, 240.

———. First supplement to a check list of the Coccidæ. Bul. Illinois State Lab. Nat. Hist., 5 (1899), pp. 389–398.

———. The Coccidæ of the Sandwich Islands. Entomologist, 32 (1899), pp. 93, 164.

*Coquillett, D. W. A new Trypetid from Hawaii. Ent. News, 10 (1899), p. 129.

Dallas, W. S. List of the specimens of hemipterous insects in the collection of the British Museum. London, 1851, p. 228; 1852, p. 577.

Dyar, H. G. Notes on the larvæ of an Hawaiian pyralid (*Orniodes accepta* Butler). Proc. Ent. Soc. Washington, 6 (1904), pp. 65, 66.

Erichson, W. F. Meyen's Beiträge zur Zoologie, gesammelt auf einer Reise um die Erde. Coleoptera und Lepidoptera. Nova Acta Acad. Caes. Leop., 1834, vol. 16, sup. 1, pp. 219–284.

Eschscholtz, F. Kotzebue's Entdeckungs-Reise in die Sud-See und nach der Berings-Strasse. Weimar, 1821, vol. 3, p. 207.

*Fairmaire, L. Essai sur les Coléoptères de la Polynésie. Extrait de la Revue et Magasin de Zoologie. Paris, 1849.

*Fernald, Mrs. M. E. A catalogue of the Coccidæ of the world. Massachusetts Expt. Sta. Bul. 88, 1903. Forty-eight species are recorded from the Hawaiian Islands.

*Grimshaw, P. H. Diptera. Fauna Hawaiiensis. Cambridge, 1901, vol. 3, pt. 1, pp. 1–77, pls. 3.

*———, and Speiser, P. Diptera (Suppl.). Fauna Hawaiiensis. Cambridge, 1902, vol. 3, pt. 2, pp. 79–92.

Holmgren, A. E. Kongliga Svenska Fregatten Eugenies Resa omkring jorden under befäl af C. A. Virgin, åren 1851–1853. Zoologi, I. Stockholm, 1858–1868.

Howard, L. O. Diptera collected in Hawaii by H. W. Henshaw. Proc. Ent. Soc. Washington, 4 (1901), No. 4, p. 490.

*Karsch, F. Zur Kafeefauna der Sandwich-, Marshall- und Gilberts-Inseln. Berlin. Ent. Ztschr., 25 (1881), pp. 1–13, pl. 1.

*Kellogg, V. L., and Chapman, B. L. Mallophaga from birds of the Hawaiian Islands. Jour. N. Y. Ent. Soc., 10 (1902), pp. 155–169, pls. 3.

Kirby, W. F. Description of a new genus of Odonata. Ann. and Mag. Nat. Hist., 7. ser., 2 (1898), pp. 346–348.

Kirkaldy, G. W. Eine neue hawaiische Fulgoriden-Gattung und Art. Ent. Nachr., 25 (1899), p. 359.

*Kirkaldy, G. W. Hemiptera. Fauna Hawaiiensis. Cambridge, 1902, vol. 3, pt. 2, pp. 93–174, pls. 2.

*———. Miscellanea Rhynchotalia, No. 7. Entomologist, 36 (1903), pp. 179, 180.

*———. Some new Oahuan (Hawaiian) Hemiptera. Entomologist, 37 (1904), pp. 174–179.

*———. A list of the Coccidæ of the Hawaiian Islands. Entomologist, 37 (1904), pp. 226–230.

*Kuwana, S. I. Coccidæ (scale insects) from Japan. Proc. Cal. Acad. Sci., 3. ser., Zool., 3 (1902), p. 65.

Maskell, W. M. Further Coccidæ notes. Trans. and Proc. New Zealand Inst., 25 (1893), pp. 201–252.

———. Synoptical list of Coccidæ from Australia and the Pacific Islands. Trans. and Proc. New Zealand Inst., 27 (1895), pp. 1–35.

———. Further Coccidæ notes. Trans. and Proc. New Zealand Inst., 27 (1895), pp. 36–75; 29 (1897), pp. 293–331.

———. On a collection of Coccidæ, principally from China and Japan. Ent. Mo. Mag., 2. ser., 8 (1897), pp. 239–244.

McLachlan, R. Neuroptera of the Hawaiian Islands. Part I (Pseudo-neuroptera). Ann. and Mag. Nat. Hist., 5. ser., 12 (1883), pp. 226–240. Part II (Planipennia). Ann. and Mag. Nat. Hist., 5. ser., 12 (1883), pp. 298–303. Supplementary note. Ann. and Mag. Nat. Hist., 6. ser., 10 (1892), pp. 176–178.

*Meyrick, E. On the Pyralidina of the Hawaiian Islands. Trans. Ent. Soc. London, 1888, pp. 209–246.

*———. Macrolepidoptera. Fauna Hawaiiensis. Cambridge, 1899, vol. 1, pt. 2, pp. 123–275, pls. 5.

———. New Hawaiian Lepidoptera. Ent. Mo. Mag., 36 (1900), p. 257.

Perkins, R. C. L. A collecting trip on Haleakala, Maui, Sandwich Islands. Ent. Mo. Mag., 32 (1896), pp. 190–195.

———. Notes on *Oligotoma insularis* McLach. (Embiidæ.) Ent. Mo. Mag., 33 (1897), pp. 56–58.

———. Notes on some Hawaiian insects. Proc. Cambridge Phil. Soc., 9 (1897), pp. 373–380.

*———, and Forel, A. Hymenoptera aculeata. Fauna Hawaiiensis. Cambridge, 1899, vol. 1, pt. 1, pp. 1–122, pls. 2, map 1.

*———. Orthoptera. Fauna Hawaiiensis. Cambridge, 1899, vol. 2, pt. 1, pp. 1–30, pls. 2.

*———. Neuroptera. Fauna Hawaiiensis. Cambridge, 1899, vol. 2, pt. 2, pp. 31–89, pls. 3.

*———. Leaf-hoppers and their natural enemies. (Pt. I, Dryinidæ; Pt. II, Epipyropidæ; Pt. III, Stylopidæ.) Hawaiian Sugar Planters' Expt. Sta., Div. Ent. Bul. 1, pts. 1–3, 1905.

*Reh, L. *Diaspis bromeliæ* Kerner. Allg. Ztschr. Ent., 9 (1904), p. 30.

Reuter, O. M. Monographia anthocoridarum orbis terrestris. Acta Soc. Sci. Fenn., 14 (1885), pp. 555–758.

Sharp, D. Description of a new species, probably indicating a new genus of Anchomenidæ from the Sandwich Islands. Ent. Mo. Mag., 14 (1877), pp. 179, 180.

———. On some Longicorn Coleoptera from the Hawaiian Islands. Trans. Ent. Soc. London, 1878, pp. 201–210.

———. On some Coleoptera from the Hawaiian Islands. Trans. Ent. Soc. London, 1879, pp. 77–105.

*———. On some new Coleoptera from the Hawaiian Islands. Trans. Ent. Soc. London, 1881, pp. 507–534.

Sharp, D. On some genera of the subfamily Anchomenini (Platynini Horn.) from the Hawaiian Islands. Ent. Mo. Mag., 20 (1884), pp. 217–219.

———. Note on the genus Plagithmysus Motsch. Ann. (Bul. ou Compt. Rend.) Soc. Ent. Belg., 1885, pp. LXXIV–LXXVI.

*———. Insects. Parts I and II. The Cambridge Natural History. London and New York, 1895, vol. 5, pp. 354, 395, 425, 471; 1899, vol. 6, pp. 22, 76.

———. On Plagithmysus: A Hawaiian genus of Longicorn Coleoptera. Ent. Mo. Mag., 32 (1896), pp. 237–245, 271–274.

———. On Plagithmysus (Suppl.). Ent. Mo. Mag., 33 (1897), p. 12.

*———, and Perkins, R. C. L. Coleoptera, I. Fauna Hawaiiensis. Cambridge, 1900, vol. 2, pt. 3, pp. 91–270, pls. 5.

*———. Coleoptera, II. Fauna Hawaiiensis. Cambridge, 1903, vol. 3, pt. 3, pp. 175–292, pls. 2.

Signoret, V. Revue iconographique Tettigonides. Ann. Soc. Ent. France, 3. ser., 2 (1854), p. 15.

Smith, F. Descriptions of new species of aculeate Hymenoptera collected by the Rev. Thos. Blackburn in the Sandwich Islands. Jour. Linn. Soc. [London], Zool., 14 (1879), pp. 674–685.

White, F. B. W. Descriptions of new species of heteropterous Hemiptera collected in the Hawaiian Islands by Blackburn, Nos. 1–3. Ann. and Mag. Nat. Hist., 4. ser., 20 (1877), pp. 110–114; 5. ser., 1 (1878), pp. 365–374; 5. ser., 7 (1881), pp. 52–59.

———. Descriptions of new Anthocoridæ. Ent. Mo. Mag., 16 (1879), pp. 146, 147.

ECONOMIC.

*Blackman, L. G. Introduction of insectivorous bats. Hawaiian Forester and Agr., 1 (1904), No. 5, p. 115.

*Chamberlain, J. E. The peelua or army worm of the Hawaiian Islands. Hawaiian Almanac and Annual for 1883. Honolulu, 1882, pp. 44–50.

*Chittenden, F. H. Fuller's rose beetle, *Aramigus fulleri* Horn. U. S. Dept. Agr., Division of Entomology Bul. 27, n. ser., 1901, p. 91.

*Clark, B. O. Importation of insectivorous birds. Hawaiian Forester and Agr., 1 (1904), No. 3, p. 53.

*Cooper, E. Address of the president. Bien. Rpt. State Bd. Hort. Cal., 4 (1893–94), p. 246.

*———. Address of the president. Rpt. State Fruit Growers' Conv. Cal., 28 (1903), p. 19.

*Coquillett, D. W. The Icerya in Honolulu. U. S. Dept. Agr., Division of Entomology, Insect Life, vol. 3, 1891, p. 329.

*Craw, A. Entomology and quarantine. Bien. Rpt. State Bd. Hort. Cal., 4 (1893–94), pp. 79, 80.

*———. Injurious insect pests found on trees and plants from foreign countries. Bien. Rpt. State Bd. Hort. Cal., 5 (1895–96), pp. 39, 41, 43, 44, 45, 46, 47, pls. 2.

*———. Entomology and quarantine. Bien. Rpt. State Bd. Hort. Cal., 5 (1895–96), pp. 127, 128, 135.

*———. A list of scale insects found upon plants entering the port of San Francisco. U. S. Dept. Agr., Division of Entomology Bul. 4, tech. ser., 1896, p. 40.

*———. Horticultural quarantine reports. Bien. Rpt. State Bd. Hort. Cal., 8 (1901–2), pp. 188, 198.

*———. Fruit flies and their exclusion. Rpt. State Fruit Growers' Conv. Cal., 28 (1903), p. 96.

*———. Report of the superintendent of entomology. Rpt. Bd. Comrs. Agr. and Forestry, Hawaii, 1 (1903–4), pp. 136–146.

*Dole, S. B. List of birds of the Hawaiian Islands. Hawaiian Almanac and Annual for 1879. Honolulu, 1878, p. 53.
*Eckart, C. F. Leaf-hopper. Circ. Hawaiian Sugar Planters' Assoc., pp. 1–6. (Distributed August, 1903.)
*———. Relative resistance of leaf-hopper eggs to various insecticides. Hawaiian Sugar Planters' Expt. Sta. Rpt. 1903, p. 75.
*Froggatt, W. W. Economic entomology in Australia. Agr. Gaz. N. S. Wales, 12 (1901), No. 1, p. 137.
*———. Report of the entomologist. Agr. Gaz. N. S. Wales, 12 (1901), No. 8, p. 918.
*Gifford, W. M. Entomological division. Hawaiian Sugar Planters' Expt. Sta. Rpt. 1904, pp. 7–12.
*Hall, W. M. L. The forests of the Hawaiian Islands. Hawaiian Forester and Agr., 1 (1904), No. 4, p. 93.
*Haughs, D. Report of the Commissioner of Agriculture. Rpt. Min. Int. Republic Hawaii for Bien. Period Ending 1899, pp. 120–123.
*Howard, L. O., and Marlatt, C. L. The San José scale. U. S. Dept. Agr., Division of Entomology Bul. 3, n. ser., 1896, pp. 10, 11.
*———. The economic status of insects as a class. Science, n. ser., 9 (1899), No. 216, p. 241.
*———. A dipterous enemy of cucurbits in the Hawaiian Islands. U. S. Dept. Agr., Division of Entomology Bul. 22, n. ser., 1900, pp. 93, 94.
*———. The Sandwich Island sugar-cane borer again. U. S. Dept. Agr., Division of Entomology Bul. 38, n. ser., 1902, pp. 102–104.
*Henshaw, H. W. Introduction of foreign birds into the Hawaiian Islands, with notes on some of the introduced species. Hawaiian Almanac and Annual for 1901. Honolulu, 1900, pp. 132–142.
*———. Complete list of the birds of the Hawaiian Possessions with notes on their habits. Hawaiian Almanac and Annual for 1902. Honolulu, 1901, pp. 54–106.
*Higgins, J. E. The banana in Hawaii. Hawaii Expt. Sta. Bul. 7, 1904, p. 32.
*Jarves, J. J. Silk culture in Hawaii. Scenes and scenery in the Sandwich Islands, 1837–1842. Boston, 1844, pp. 105–112, 164–169.
*Judd, A. F. Horn-fly. Proc. Hawaiian Live Stock Breeders' Assoc. 1902, pp. 25, 26.
*———. Lantana destroying bugs. Proc. Hawaiian Live Stock Breeders' Assoc. 1902, pp. 24, 25.
*———. Lantana destroying insects. Proc. Hawaiian Live Stock Breeders' Assoc. 1903, p. 32.
*———. Horn-fly. Proc. Hawaiian Live Stock Breeders' Assoc. 1903, p. 33.
*———. Horn-fly. Proc. Hawaiian Live Stock Breeders' Assoc. 1904, p. 15.
*Kirkaldy, G. W. Insects of economic importance recorded from the Hawaiian Islands. Hawaiian Forester and Agr., 1 (1904), pp. 152–159, 183–189, 205, 210.
*———. Report of entomological division. Hawaiian Sugar Planters' Expt. Sta, Rpt. 1904, pp. 25–28.
*———. Report of acting superintendent of entomology. Rpt. Bd. Comrs. Agr. and Forestry Hawaii, 1 (1903–4), pp. 122–135.
*Koebele, A. Report of the entomologist. Bien. Rpt. Min. Int. Provis. Govt. Hawaiian Islands, 1894, pp. 98–104.
*———. Report on insect pests of sugar cane. Hawaiian Planters' Mo., 15 (1896), No. 12, pp. 590–598.
*———. Report of entomologist from appointment to December 31, 1896. Hawaiian Planters' Mo., 16 (1897), No. 2, pp. 65–85.
*———. Report of the entomologist to the Hawaiian Government for the two years ending December 31, 1897. Hawaiian Planters' Mo., 17 (1898), pp. 208–219, 258–269.

*Koebele, A. Report of the entomologist of the Hawaiian Government. Rpt. Min. Int. Republic Hawaii, 1898, pp. 78–89.
*———. Entomologist's report. Hawaiian Sugar Planters' Expt. Sta. Rpt. 1900, pp. 40–42.
*———. Hawaii forest foes. Hawaiian Almanac and Annual for 1901. Honolulu, 1900, pp. 90–97.
*———. Report of the entomologist. Rpt. Comr. Agr. and Forestry, Hawaii, 1900, pp. 36–49.
*———. Destruction of forest trees. Rpt. Comr. Agr. and Forestry, Hawaii, 1900, pp. 50–60.
*———. Insects affecting koa trees. Rpt. Comr. Agr. and Forestry, Hawaii, 1900, pp. 61–66.
*———. Fuller's rose beetle in the Hawaiian Islands. U. S. Dept. Agr., Division of Entomology Bul. 30, n. ser., 1901, p. 88.
*———. Insect pests of sugar cane. Hawaiian Planters' Mo., 21 (1902), No. 1, pp. 20–28.
*———. Report on lantana scale, *Orthezia insignis* Douglas. Rpt. Comr. Agr. and Forestry, Hawaii, for Bien. Period Ending Dec. 31, 1902, pp. 54–65.
*Kotinsky, J. Report of assistant entomologist. Rpt. Bd. Comrs. Agr. and Forestry Hawaii, 1 (1903–4), pp. 147–159.
*———. A circular of information. Bd. Comrs. Agr. and Forestry, Hawaii, Div. Ent. Circ. 1, 1905, p. 8.
*Marlatt, C. L. Insect control in California. U. S. Dept. Agr., Yearbook 1896, p. 226.
*Marsden, J. Report of the Commissioner of Agriculture and Forestry. Rpt. Min. Int. Republic Hawaii, 1894, pp. 31–38.
*———. Report of the Commissioner of Agriculture and Forestry. Rpt. Min. Int. Republic of Hawaii, 1895, pp. 118–120.
*Maxwell, W. The Hawaiian Islands. U. S. Dept. Agr., Yearbook 1898, p. 574.
Perkins, R. C. L. The introduction of beneficial insects into the Hawaiian Islands. Nature, 55 (1897), No. 1430, p. 499.
*———. Notes on insects injurious to cane in the Hawaiian Islands. Hawaiian Planters' Mo., 21 (1902), No. 12, pp. 593–600.
*———. Injurious and beneficial insects of Hawaii. Rpt. Governor Ter. Hawaii, 1902, pp. 31–37.
*———. The leaf-hopper of the sugar cane. Bd. Comr. Agr. and Forestry, Hawaii, Bul. 1, 1903, pp. 38.
*———. Enemies of lantana. Proc. Hawaiian Live Stock Breeders' Assoc. 1902, pp. 28–35.
*———. Cane diseases and their relation to the leaf-hopper. Hawaiian Forester and Agr., 1 (1904), No. 4, pp. 80–84.
*———. Introduction of bats. Hawaiian Forester and Agr., 1 (1904), No. 6, pp. 138, 139.
*———. Report to the Board of Commissioners of Agriculture and Forestry of the Territory of Hawaii on economic entomology. Hawaiian Forester and Agr., 1 (1904) No. 4, pp. 75–80.
*———. Later notes on lantana insects. Proc. Hawaiian Live Stock Breeders' Assoc. 1903, pp. 58–61.
*———. Report of assistant superintendent of entomology. Rpt. Bd. Comrs. Agr. and Forestry Hawaii, 1 (1903–4), pp. 119–121.
*———. Entomology. Rpt. Governor Ter. Hawaii 1904, pp. 103, 104.
*Riley, C. V. Sandwich Island sugar-cane borer (*Sphenophorus obscurus* Boisd.). U. S. Dept. Agr., Division of Entomology, Insect Life, vol. 1, 1888, p. 185.

*Riley, C. V. Report of the Entomologist. U. S. Dept. Agr., Report of the Secretary of Agriculture, 1891, p. 234.
*———, and Howard, L. O. Introduction of Icerya into Honolulu. U. S. Dept. Agr., Division of Entomology, Insect Life, vol. 3, 1891, p. 307.
*———, ———. An injurious Hawaiian beetle (*Adoretus umbrosus*). U. S. Dept. Agr., Division of Entomology, Insect Life, vol. 6, 1893, p. 43.
*Rolfs, P. H. Pineapple growing. U. S. Dept. Agr., Farmers' Bul. 140, 1901, p. 40.
*Smith, J. G. Annual report of the Hawaii Agricultural Experiment Station for 1901. U. S. Dept. Agr., Office of Experiment Stations Rpt. 1901, p. 378.
*———. Annual report of the Hawaii Agricultural Experiment Station for 1902. U. S. Dept. Agr., Office of Experiment Stations Rpt. 1902, pp. 323–325.
*———. Annual report of the Hawaii Agricultural Experiment Station for 1903. U. S. Dept. Agr., Office of Experiment Stations Rpt. 1903, pp. 414–418.
*Swezey, O. H. Life history of *Liburnia campestris*, with notes on a hymenopterous parasite infesting it. U. S. Dept. Agr., Division of Entomology Bul. 46, n. ser., 1904, p. 46.
*Terry, F. W. Insects of economic importance recorded from the Hawaiian Islands. Hawaiian Forester and Agr., 1 (1904), pp. 273–275, 299–302, 349–352; 2 (1905), pp. 70–73.
*———. Report of assistant entomologist. Hawaiian Sugar Planters' Expt. Sta. Rpt. 1904, pp. 28-30.
*Townsend, C. H. T. Some Mexican and Japanese injurious insects. U. S. Dept. Agr., Division of Entomology Bul. 4, tech. ser., 1896, p. 10.
*Thomas, W. B. Farming in Hawaii. Hawaiian Almanac and Annual for 1901. Honolulu, 1900, pp. 124–128.
*Thrum, T. G. Notes on the history of the sugar industry in the Hawaiian Islands. Hawaiian Almanac and Annual for 1875. Honolulu, 1874, pp. 35, 42.
*———. Notes on the history of coffee culture in the Hawaiian Islands. Hawaiian Almanac and Annual for 1876. Honolulu, 1875, p. 49.
*———. Bureau of Agriculture and Forestry. Hawaiian Almanac and Annual for 1894. Honolulu, 1893, pp. 93, 94.
*———. Coffee outlook in Hawaii. Hawaiian Almanac and Annual for 1895. Honolulu, 1894, p. 67.
*Van Dine, D. L. Insecticides for use in Hawaii. Hawaii Expt. Sta. Bul. 3, 1903, pp. 25, figs. 7, pl. 1.
*———. The question of a remedy for the leaf-hopper on the sugar cane. Circ. Hawaiian Sugar Planters' Assoc., pp. 7–13. (Distributed August, 1903.)
*———. Mosquitoes. Hawaii Expt. Sta. Press Bul. 7, 1903, figs. 2. (A cardboard poster, 9 by 14 in., printed in English, Portuguese, Hawaiian, Chinese, and Japanese.)
*———. The mealy-bug of the alligator pear, *Dactylopius nipæ* Mask. Hawaii Expt. Sta. Press Bul. 8, 1903, pp. 6, figs. 3.
*———. Insecticides for use in Hawaii. Hawaii Expt. Sta. Bul. 3, rev. ed., 1904, pp. 21, figs. 7, pl. 1.
*———. A sugar-cane leaf-hopper in Hawaii, *Perkinsiella saccharicida* Kirk. Hawaii Expt. Sta. Bul. 5, 1904, pp. 29, figs. 8.
*———. Mosquitoes in Hawaii. Hawaii Expt. Sta. Bul. 6, 1904, pp. 30, figs. 12.
*———. The pineapple scale, *Diaspis bromeliæ* Kerner. Hawaiian Forester and Agr., 1 (1904), No. 5, pp. 111–114.
*———. The mosquito—where it lives and how it lives. (Elementary.) Hawaii's young people. Dept. Public Instr., Ter. Hawaii. Lahainaluna, 1904, pp. 332–335.
*———. The pineapple scale, *Diaspis bromeliæ* Kerner. Hawaii Expt. Sta. Press Bul. 10, 1904, pp. 6, fig. 1.

Van Dine, D. L. Notes on insect work in Hawaii. The Pacific Commercial Advertiser. Honolulu, January 23, 1905.

*———. A partial account of insects affecting tobacco in Hawaii. Hawaiian Forester and Agr., 2 (1905), pp. 31–36, 76–79, 98, 99, 162–166.

*———. Annual report of the Hawaii Agricultural Experiment Station for 1904. U. S. Dept. Agr., Office of Experiment Stations Rpt. 1904, pp. 372–379.

*———. The mango weevil in Hawaii, *Cryptorhynchus mangiferæ* Fab. Hawaiian Forester and Agr., 2 (1905), No. 8, pp. 231–233.

*———. Insect enemies of tobacco in Hawaii. Hawaii Expt. Sta. Bul. 10, 1905, pp. 16, figs. 6.

*———. The pineapple scale, *Diaspis bromeliæ* Kerner. Hawaii Expt. Sta. Press Bul. 10, 2d reprint, 1905, pp. 6, fig. 1.

REPORT OF THE HORTICULTURIST.

By J. E. Higgins.

CACAO.

The work on the growing of cacao at Hilo, mentioned in the report for the fiscal year 1904, has been begun and is well under way. A tract of 3 acres has been cleared, plowed twice, subsoiled in part, and prepared for the cacao plants. The field was laid off in five sections, in which cacao trees of different varieties will be experimented with under different methods of treatment. The relative advantages of wide and narrow planting is being tested, including an experiment in double planting, with a view to removing half or possibly three-quarters of the trees as they increase in age and before they become crowded.

Through the courtesy of Hon. E. W. Gurr, of Tutuila, Samoa, the station has received seeds of several varieties. These were planted in some of the sections of the field and also in nursery row. It is not a common practice to plant this tree in nursery form because of the difficulty of removing it in safety. It is a somewhat current belief that it is ruinous to a cacao tree to injure its tap root, but this should probably not be accepted without qualification. Tests will be made in removing the nursery trees.

Through the cooperation of the Bureau of Plant Industry, U. S. Department of Agriculture, this station is promised a collection of the more important and promising varieties of cacao from different parts of the Tropics. These plants, when received, will be planted at once in the field at Hilo.

BANANAS AT HILO.

In connection with the cacao work at Hilo, many experiments with bananas are being carried on. The cacao requires shade, and no plant furnishes a better temporary protection than does the banana. This affords an opportunity to make the land do double duty from an experimental point of view. In the interests of commercial banana

growing, which has become quite important at Hilo and the surrounding country, experiments are being carried on with different methods of planting and caring for bananas. It is a somewhat common practice to plant very deeply, regardless of variety, soil, or other conditions. The experiments have already shown that this practice must be modified, but they have not yet reached completion.

It was believed also that a mistake was being made by many planters in the use of very small off-sets. Consequently, a test was begun in the use of off-sets of all sizes as well as of old corms. These experiments are not yet far enough advanced to show conclusive results, but the evidence is in favor of large plants.

The fertilizing of bananas is an important question among the banana growers of Hilo. In a plat devoted to the Chinese, or Cavendish banana, which is the commercial variety in the islands, a fertilizer experiment has been begun in which many different combinations of fertilizing ingredients have been applied. It is believed that the results of these tests will throw some valuable light upon this question, which is of great importance to the industry.

A collection of a large number of native and recently introduced bananas occupies one of the sections, together with 150 or 200 stools of the Bluefields or Jamaica variety, which is being propagated as rapidly as possible for distribution by the territorial board of agriculture and forestry, in cooperation with which the work with this variety is being carried on.

A new commercial variety, it is believed, will be found in the form locally known as the Brazilian, which is probably the same as the Pisang Radjah, or the Pisang Medgi of Java. This variety has not been exported because of its habit of falling from the bunch when thoroughly ripe. It is, however, so superior to the Cavendish variety in many ways that we believe it will pay for greater care in handling when its merits come to be known. In point of flavor it far exceeds any banana now in the American market and is excelled by none grown in the Territory. It seems to be much less subject to some of the diseases which mar the appearance of the Chinese banana and is very much more attractive, being of a clear, yellow color. A large part of the temporary shade for cacao at the Hilo plantation is composed of this variety of banana, the intention being to make experimental shipments of the fruit later to San Francisco.

SHIPMENT AND COLD STORAGE OF TROPICAL FRUITS.

This is a subject which is worthy of much attention. As a beginning a shipment of avocados was made to New York City late in the summer of 1904. These fruits were packed in various ways and received somewhat different treatment before shipment. The results

of the experiments are very encouraging in that some of the packages arrived in excellent condition. A few of the fruits were forwarded to Washington, D. C., and were there pronounced by experts to be very fine in flavor. It was, unfortunately, late in the season before arrangements could be completed for making the shipment, and the fruit, being rather too far advanced, the chances were decidedly against its arrival in good condition. At the same time that the shipment was made a few packages of the fruit were placed in cold storage in Honolulu.

The results of these experiments, while not conclusive, point to a decided advantage to be derived from placing the fruits in cold storage as soon as possible after gathering. The ripening process soon begins, especially with fruit which has been rather too long on the trees, and once under way it is difficult to arrest it.

The matter of correct storage temperatures for these and other tropical fruits is one which must yet be worked out. It is quite possible that higher temperatures than those used for temperate zone fruits would be a distinct advantage. The fruits which were kept in the ice house in Honolulu were preserved in good condition and retained their flavor apparently unimpaired for some time after the shipment arrived in New York. After being kept for many weeks, the first signs of deterioration were manifest in a darkened color of the flesh and loss of flavor, though the fruit remained solid. Hence it is quite possible that higher temperatures would prove more successful.

In the matter of packages it seems probable that small forms are preferable. Some of the fruits in the New York shipment were placed in individual sections, such as are used for the packing of glass jelly jars, but no advantage was apparent from this method. The test, however, was not exhaustive enough to be conclusive.

CITRUS FRUITS.

Over 60,000 dollars' worth of citrus fruits are imported annually in the Hawaiian Islands, a territory which affords a congenial home for almost all the species of citrus. To aid those who would grow these fruits, either in the home garden or on a commercial scale, a study has been made of the local conditions relative to this culture and a bulletin (No. 9) treating of the subject has been published. Experimental work has been commenced to determine the merits of different stocks for use in propagating oranges, lemons, limes, and pomelos under Hawaiian conditions.

There are several Hawaiian seedlings of oranges, pomelos, and limes which are of sufficient merit to warrant their perpetuation by budding.

THE MANGO.

Studies of the mango have been continued throughout the year as opportunity offered. Observations were made and records kept of the time of blooming, of the maturing of the fruit, and of the periods of most active growth. About the first of January the mango trees begin to bloom, and by June 30, this season, the mango crop was coming in rapidly. For most varieties the fruiting season was about over by August 1. The seasons, however, vary from year to year, and because sections of the tree often bloom out of season mangoes can be found throughout a large part of the twelve months.

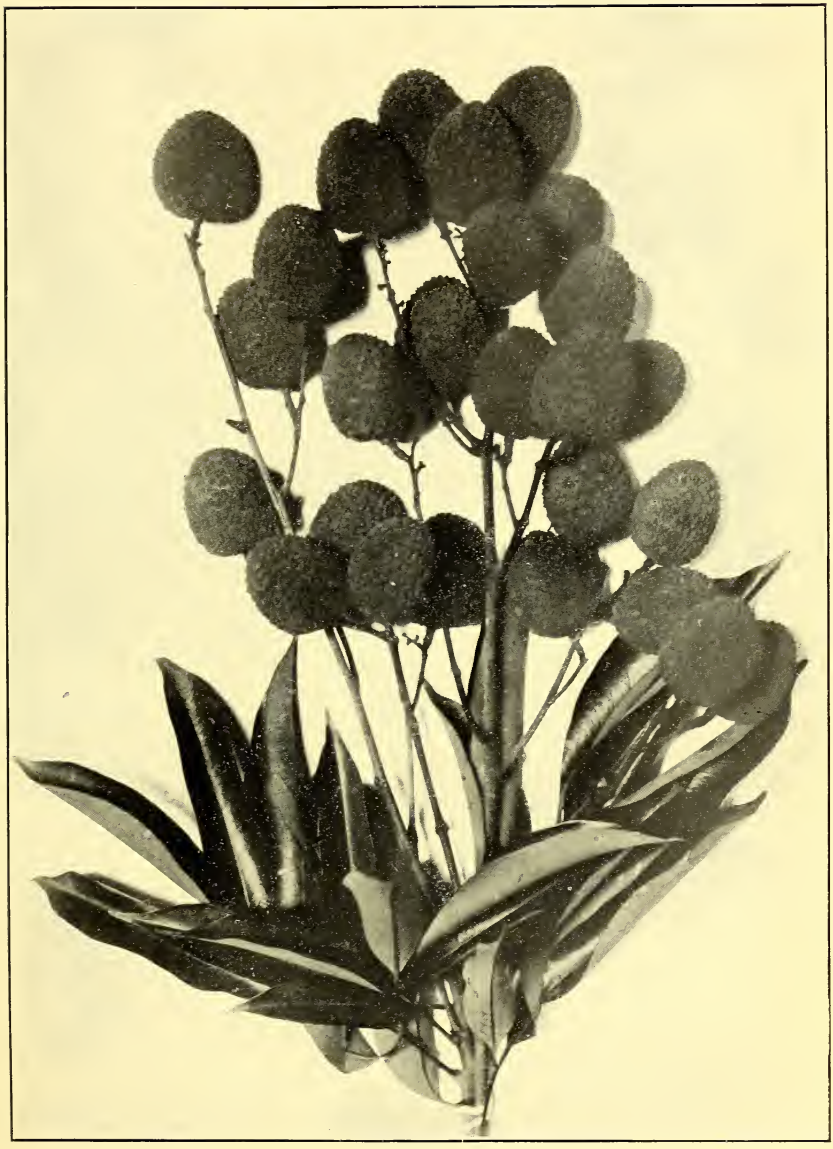
Studies have been made of the habits of growth and fruit production in relation to pruning. The mango requires but little pruning to make it assume a desirable form, but it seems probable that its habit of overbearing one year and producing no crop the next might be overcome by judicious pruning and perhaps by thinning the fruit. It is hoped to take up experiments in pruning with this end in view.

The mango disease mentioned in last year's report, which is due to a species of the fungus Colletotrichum, has been still further studied in cooperation with the laboratory of Vegetable Pathological and Physiological Investigations of the U. S. Department of Agriculture. This fungus has been found present, not only in the fruits, flowers, and young leaves, but also in the old leaves and mature twigs, in some instances apparently destroying the terminal bud before it opened. Experiments in spraying with Bordeaux mixture have been carried on with very encouraging results.

An abnormal character in young mango fruits has been noticed which closely resembles verrucosis of the lemon in outward aspect, but seems to disappear as the fruit increases in size. The cause of this abnormal development has not been discovered. A bulletin (No. 12) has been prepared covering in more detail this and other work on the mango.

EXPERIMENTAL PLATS IN HONOLULU.

In the experimental plats at the lower end of the station lands have been grown 7 varieties of cotton, 2 varieties of papaias, 150 mango seedlings, wood-oil nuts, *Centrosema plumeri*, *Canavalia gladiata* and other leguminous green manuring crops, Manila hemp (*Musa textilis*), *Hibiscus abelmoschus*, and other fiber-producing plants, sugar cane, about 40 varieties of bananas, including several hundred plants of the Bluefields or Jamaica variety, 6 varieties of sorghum and Kafir corn, Rosella (*Hibiscus sabdariffa*), pineapples, garden vegetables, and flowers, cassava, and several other species of economic plants.



LITCHI (NEPHELIUM LITCHI), FRUIT AND LEAVES.

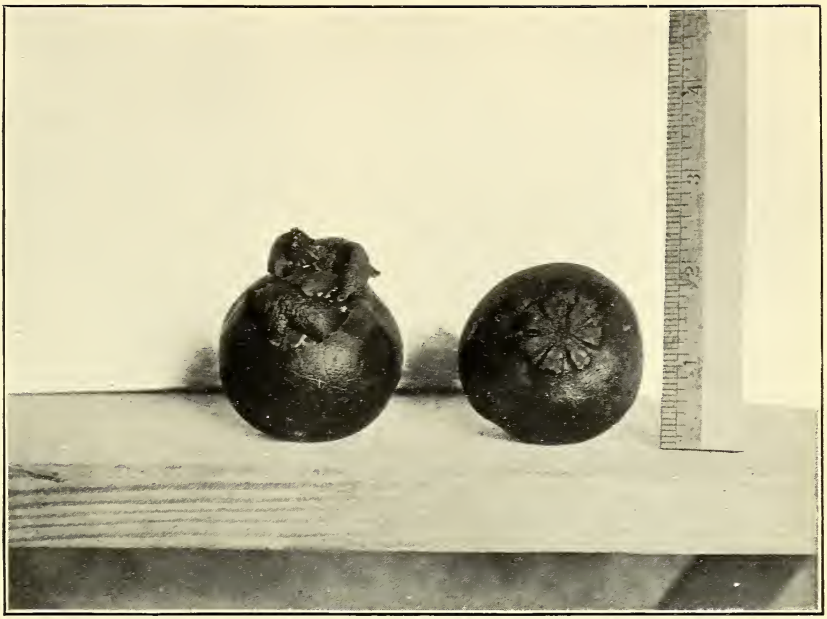


FIG. 1.—MANGOSTEEN (GARCINIA MANGOSTANA).

FIG. 2.—WI FRUIT (SPONDIAS DULCIS).

MISCELLANEOUS HORTICULTURAL PRODUCTS.

There continue to be inquiries regarding the cultivation of vanilla. There are in the islands one or two established plantations of vanilla, the best known being that of Mr. Edwards on Hawaii. A brief account of the culture and curing of vanilla has been given in Press Bulletin No. 6 of the station.

The dried fruit of the litchi (see Pl. III) is becoming more extensively known in the markets of the United States, and the successful efforts to grow the trees in Hawaii indicate the possible success of more extensive plantings. The dried fruits from China sell in the Washington market for about 50 cents a box, containing about 1 quart, and the demand for the very limited production in Hawaii is such that the price is very dear.

Attempts are being made by the station in cooperation with the Bureau of Plant Industry of the U. S. Department of Agriculture to introduce more widely the mangosteen in Hawaii. There are already a few trees of this delicious fruit (see Pl. IV, fig. 1) growing in the islands and efforts are being made to propagate others. The tree is of slow growth, and the proper conditions for culture are yet to be ascertained. The successful germination of locally grown seed is reported.

Another fruit that merits attention is the Wi fruit (*Spondias dulcis*). (See Pl. IV, fig. 2.) It is also known as Tahiti apple. It is produced on a tree that attains a height of 50 feet. The fruit is a golden yellow and resembles a pineapple in flavor. It is a native of the South Sea Islands and is now rather widely distributed throughout the Tropics.

A variety of papaias received from Porto Rico Experiment Station as the best form to be found in that island has also proved successful here. Though it has not under our conditions proved itself equal in flavor to some varieties which have been longer in cultivation here, it is worthy of a place in cultivation and will be a valuable addition to the list of forms in Hawaii. It seems to have a more active aperient quality than the local papaias.

Centrosema plumeri promises to be a very successful green manuring crop. These seeds also were received from the Porto Rico Station and have been multiplied here. The plants make a very rapid growth after they get well started and cover the land with a dense mass of foliage which soon begins to decay from below but increases above.

The wood-oil nuts which were received from the Section of Seed and Plant Introduction and Distribution, U. S. Department of Agriculture, consisted of two lots—one in the hulls and the other without hulls. The latter were nearly a total failure, only four or five seeds germinating. The other lot received in the hulls were in good condition, and a very large percentage have made a good start.

The Rosella (*Hibiscus sabdariffa*) has been little cultivated in Hawaii, though it is quite common in Australia, and was long ago introduced to these islands from that source. It makes a good growth on the station grounds, and it is hoped that it will fruit freely. The large fleshy calyx of the flower is both useful and ornamental. It is this part of the plant which is used in the making of a jam which closely resembles in color and flavor that made from cranberries.

At the upper lands, where the rainfall is the only water supply, have been planted coffee, bananas, carnations, violets, and garden vegetables. Some of the land has been cleared of underbrush and terraced, and is now ready for further planting. The mango and avocado trees, which were planted there in the forest before the establishment of the station, have received care and attention so far as available funds would allow. The other trees surrounding them and which threatened their life having been removed several years ago, they are now in promising condition and form quite an orchard of these two tropical fruits.

DISEASES OF PLANTS.

Several plant diseases have received attention during the year. Two diseases of the banana have caused considerable loss, the one being the "ripe rot" and the other the "banana scab."

RIPE ROT.

The ripe rot, or banana anthracnose, is due to the attack of the fungus *Glœosporium musarum*. The disease makes its first appearance on the fruit in the form of small black spots which may increase in area until the whole banana is blackened. This not only destroys its appearance but results in the decay of the fruit before ripening. The fruiting stage of the fungus is marked by roseate tints in which areas spores are readily found in large numbers.

The methods for the control of this disease must consist in precautionary measures and possibly in the use of the copper solutions. Too much stress can not be laid upon the importance of packing the fruit dry. Wet packing and stowing in the hold of the vessel furnish ideal conditions for the growth of the fungus. Decaying fruit should not be left about the fields or packing sheds, as this would furnish millions of spores for the further spread of the disease. Bordeaux mixture and the ammoniacal solution of copper carbonate have not been tested, but from the general character of the disease it is believed that their use is to be recommended at least experimentally.

BANANA SCAB.

Banana scab makes its appearance in rusty fissures in the rind of the fruit. As it increases, the whole banana may become brownish in color, and though the interior may not be injured many such fruits will render a bunch unsalable.

The fungus which causes this disease has not been fully determined. Its appearance has been observed in several countries, notably in New South Wales, where it has been studied by Dr. N. A. Cobb, who speaks of the spores as "of some Phoma-like form."

The disease is widespread throughout the islands but is not serious except on the higher elevations, where the banana makes a slow growth. The copper solutions are to be recommended for the treatment of this disease also. It is important to establish the vigor of the plant by cultivation and fertilization and to avoid the attempt to grow bananas commercially in climates unsuited to them. The fruits should be kept clear of the cast-off bracts and other matter which might hold dampness and thus furnish suitable conditions for the growth of the fungus.

NEMATODES IN BANANAS.

Quite frequently banana plants are found in which the young growing leaves are decaying. Several such plants were observed in June among those planted for shade for the cacao at Hilo. Microscopic examination revealed the presence of myriads of nematode worms which it is believed were the sole cause of the injury. It is nevertheless true that nematode worms have been reported in connection with several banana troubles where fungi were also present.

When a plant is affected as above described it is best to dig out the whole stool, and, after fertilizing liberally, to replant with an offset from a healthy plant.

NEMATODE WORMS IN COFFEE.

In the month of May inquiry came from Kona, Hawaii, in regard to a so-called disease of coffee which was reported to be doing much damage to the crop, causing a large part of it to fall from the trees. A small quantity of the berries was received and an examination was made for evidences of fungi. None were found, however, but nematode worms in large numbers were inhabiting the stem end of the berry and were probably the cause of the falling fruit. Nothing can be recommended in the way of treatment except to increase the vigor of the trees in every way possible.

31208—No. 170—06——5

FARMERS' INSTITUTE.

The horticulturist has acted as secretary-treasurer of the farmers' institute of Hawaii. Four meetings have been held during the year, at each of which three or more papers or lectures have been presented. The membership has been increased so that sufficient funds have been secured to meet the minor incidental expenses of the institutes. No Government funds are available for the carrying on of this work. An arrangement has been made with the Hawaiian Forester and Agriculturist, the local agricultural periodical, so that all papers presented at the meetings are now published and thus made available to everyone in the Territory and also are preserved in permanent form.

O